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USSR Report

ENGINEERING AND EQUIPMENT

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CONTENTS

NUCLEAR ENERGY

Comparison of VVER-440, VVER-1000 Nuclear Power Plants
(Gabor Bede; ENERGIA ES ATOMTECHNIKA, No 1, Jan 86)..... 1

Regulation of High-Frequency Characteristics of Linear Electron Accelerator
(A.N. Filatov, V.K. Shilov; PRIBORY I TEKHNIKA EKSPERIMENTA, No 6, Nov-Dec 85)..... 10

Linear Inductive Accelerator
(V.V. Vasilyev, G.G. Kanayev, et al.; PRIBORY I TEKHNIKA EKSPERIMENTA, No 6, Nov-Dec 85)..... 10

NON-NUCLEAR ENERGY

Commentary on Siberian Oilfield Equipment Supply Problems
(SOVETSKAYA ROSSIYA, 9 Jan 86)..... 12

Geological Production Station in the 12th Five-Year Plan
(NEFTYANOYE KHOZYAYSTVO, No 2, Feb 86)..... 16

The Use of Fuel and Water Emulsions in Shipboard Diesel Installations
(Yu.I. Vorzhev, K.K. Gimbutis; SUDOSTROYENIYE, No 7, Jul 85)..... 18

Stress Characteristics of Ship Propellers With Scimitar Blades
(I.A. Titov, L.I. Vishnevskiy, et al.; SUDOSTROYENIYE, No 10, Oct 85)..... 31

Effect of Windmilling Inlet Devices on Performance of Ship Compressors and Fans
(V.L. Zhokhov; SUDOSTROYENIYE, No 10, Oct 85)..... 33

Selection of Optimum Temperature Difference in Design of Air Cooling Systems
(A.G. Ionov, V.N. Erlikhman, et al.; SUDOSTROYENIYE, No 12, Dec 85)..... 35

Thin-Film Oil Cooler
(Ye.V. Glubokov; SUDOSTROYENIYE, No 12, Dec 85)..... 35

Superhard Materials for Axial Bearings
(G.A. Gunbin, Ye.O. Bryanskaya, et al.; SUDOSTROYENIYE, No 12, Dec 85)..... 36

CONSTRUCTION

Support Column of Reinforced Concrete for Megawatt Wind Power Plant
(K.Z. Galustov, O.L. Perfilov, et al.; BETON I ZHELEZOBETON, No 2, Feb 86)..... 37

Experience With Use of Fly Ash for Production of Concrete Mixes
(Ye.V. Luzhko, I.I. Zadolinnyy, et al.; BETON I ZHELEZOBETON, No 2, Feb 86)..... 38

INDUSTRIAL TECHNOLOGY

Control of Flexible Manufacturing System Modules in Typical Situations
(V.K. Anikin, A.I. Savitskiy; TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA, No 1, Jan 86)..... 39

Manufacturing Process Planning in Spinning of Shell-Type Parts on NC Machine Tools
(P.F. Grigoryev, N.Ye. Gayvoronskaya; TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA, No 1, Jan 86)..... 42

Development and Introduction of Control Programs for Oxygen Cutting Machines of 'Kristall' Type
(A.P. Palnikov, P.A. Davydenko; TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA, No 1, Jan 86)..... 44

Effectiveness of Utilization of Substitutes for Metal in Machine Building
(B.V. Senchenko, A.V. Kozenko; TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA, No 1, Jan 86)..... 46

Editorial Urges Economizing in Die Forging
(KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO, No 2, Feb 86)..... 48

Exhibition of Products Embodying New Technology
(A. Kondrashov; EKONOMICHESKAYA GAZETA, No 10, Mar 86)... 51

Newly Re-Equipped Machine Building Plant Still Not Meeting Delivery Schedule
(Ch. Sadykhov, Z. Kuperman; BAKINSKIY RABOCHIY, 7 Jan 86)..... 55

Programmable Positioning Jig for Radial Drilling Machines
(S.I. Gontarevskiy; TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA, No 1, Jan 86)..... 58

New Process for Making Worker Rolls for Multiroll Helical Rolling Mills
(A.A. Kuz'minykh, V.A. Polozovskiy, et al.; KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO, No 12, Dec 85)..... 60

Automated System Based on 63 kN Model AKKD 2118A.03 Single-Crank Press
(Ye.F. Kuchmeyev, V.V. Goshtalek, et al.; KUZHECHNO-SHTAMPOVOCHENOYE PROIZVODSTVO, No 12, Dec 85).. 61

New Technological Process and Equipment for Tape Finning of Tubes
(V.P. Mulin, N.I. Chernikin; KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO, No 12, Dec 85)..... 67

A Plasmatron Manipulator for a Vertical Boring and Turning Machine
(V.P. Vlasov; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 12, Dec 85)..... 70

A Robotic Technology Complex for the Forming of Transformer Plates
(G.Ye. Vasilyev, S.N. Sanayev, et al.; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 12, Dec 85)..... 72

Experience in the Development and Introduction of Robotic Technology Complexes (RTC) for Cold Forming
(Ye.V. Novoselskiy, I.N. Svechkov, et al.; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 12, Dec 85)..... 75

A 'Robot Service'
(Ye.B. Finkol; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 12, Dec 85)..... 79

Productivity Analysis of Flexible Manufacturing Systems by Methods Based on Theory of Queueing Networks
(N.M. Ganin, V.Ya. Katkovnik; MASHINOSTROYENIYE, No 2, Mar-Apr 86)..... 81

Characteristics of Regular Robotic Structures With Cyclic Control
(L.I. Tyves, A.N. Sonin; MASHINOVEDENIYE, No 1, Jan 86).. 82

Structural Synthesis of Automatic Technological Machinery for Processing of Heavily Filled Thermosetting Plastics
(A.D. Sokolov; MASHINOVEDENIYE, No 1, Jan 86)..... 83

Solution of Inverse Problem of Manipulator Positioning by Method of Screws
(V.A. Glazunov; MASHINOVEDENIYE, No 1, Jan 86)..... 83

Elastohydrodynamic Problem in Theory of Lubrication for Two-Layer Radial Sliding Bearings
(V.N. Prokopyev, A.A. Muravyev; MASHINOVEDENIYE, No 1, Jan 86)..... 84

Robotized Plant for Manufacture of Fiberglass Products
(G.P. Vinogradov, S.V. Listov, et al.; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 1, Jan 86)..... 85

Automatic Control of Center Drive in Parts Machining Facility
(V.A. Zaderenko; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 1, Jan 86)..... 86

Automating On-Line Control of Production Lines With NC Equipment
(B.S. Shalimov, S.B. Shestoperov; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 1, Jan 86)..... 86

Dynamic Characteristics of Gas-Lubricated Thrust Bearings
(Ye.G. Grudskaya, Yu.V. Borisova; MASHINOVEDENIYE, No 4, Jul-Aug 85)..... 87

Method of Correcting Spatial Configuration of Bent Pipe
(N.A. Serkov, Ye.I. Pan; MASHINOVEDENIYE, No 4, Jul-Aug 85)..... 88

Cost Effectiveness of Metrological Certification of Engineering Measurement Procedures Using Measuring and Information Systems
(M.F. Natalyuk, Yu.R. Kalitsinskiy, et al.; IZMERITEL'NAYA TEKHANIKA, No 1, Jan 86)..... 88

New Indicator of Workshop Performance in Enterprises With Automatic Production Control
(V.V. Mikheyev, Yu.L. Moyzhes, et al.; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 2, Feb 86)..... 89

Organization of Data Acquisition From Video Terminals of Automatic Control System for Technological Processes in Petroleum Reshipment Port
(V.G. Voronenko; MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA, No 2, Feb 86)..... 90

TURBINE AND ENGINE DESIGN

Estimating Change in LMZ K-210-130 Turbine Efficiency Between Overhauls
(S.V. Rybachkov, Ya.D. Berkovich, et al.; ENERGETIK, No 1, Jan 86)..... 91

Determination of Temperature of Inlet Guide Vane Surface in Axial Compressor To Prevent Icing
(V.N. Osipov; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA, No 3, Jul-Sep 85)..... 95

Dependence of Flow Pattern in Diffuser on Velocity Profile in Entrance Section
(A.A. Turilov, G.M. Shalayev; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA, No 3, Jul-Sep 85)..... 96

Optimum Relation Between Elastic and Damping Components of Rotor Bearings
(D.Ye. Chegodayev; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA, No 3, Jul-Sep 85).... 96

Some Features of Flow Along Turbine Blades With Film Cooling
(V.K. Milovanov; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA, No 3, Jul-Sep 85).... 97

Measurement of Soot Emission From Combustion Chamber of Gas Turbine Engine
(O.V. Strogonov, V.S. Varfolomeyev, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA, No 3, Jul-Sep 85)..... 97

Design of Head of Automobile Engine Piston for Discrete Strength Equalization
(V.P. Malkov, V.P. Povelikin, et al.; MASHINOVEDENIYE, No 4, Jul-Aug 85)..... 98

Effect of Structural Factors on Performance of Axial Bearings During Longitudinal Vibrations of Turbine Set Foundations
(I.Ya. Tokar, B.P. Kalinin; MASHINOSTROYENIYE, No 4, Jul-Aug 85)..... 99

High-Economy Diesel Engines for Ships
(L.P. Sedakov, F.M. Yelistratov; SUDOSTROYENIYE, No 11, Nov 85)..... 99

HIGH-ENERGY DEVICES, OPTICS AND PHOTOGRAPHY

Radiometric Apparatus for Optical Measurements Along Ballistic Path
(Ye.P. Andreyev, N.N. Baulin, et al.; PRIBORY I TEKHNIKA EKSPERIMENTA, No 3, May-Jun 85)..... 101

Metal-and-Glass Low-Voltage Electron Diffractometer
(S.A. Knyazev, Yu.B. Vymorkov; PRIBORY I TEKHNIKA EKSPERIMENTA, No 3, May-Jun 85)..... 102

High-Speed Precision Photometer for Automatic Microdensitometer
(M.P. Grishin, Sh.M. Kurbanov, et al.; PRIBORY I TEKHNIKA EKSPERIMENTA, No 6, Nov-Dec 85)..... 103

Determination and Automatic Regulation of Optical Thickness of Scanning Fabry-Perot Interferometer
(Yu.V. Yevdokimov, L.L. Kravchinskiy, et al.; PRIBORY I TEKHNIKA EKSPERIMENTA, No 6, Nov-Dec 85)..... 103

Instruments for Measurement of Alternating Magnetic Induction at Cryogenic Temperatures and Their Metrological Quality Assurance
(D.R. Vasilyev, Yu.I. Kazantsev, et al.; IZMERITEL'NAYA TEKHNIKA, No 1, Jan 86)..... 104

FLUID MECHANICS

Aerodynamic Airfoil Design for Nonseparation Flow
(Z.Kh. Nugmanov, V.A. Ovchinnikov, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA, No 3, Jul-Sep 85)..... 106

Asymptotic Models With First and Second Approximations Describing Interaction of Two Streams During Supersonic Flow Around Bodies With Injection
(S.I. Blokhin, A.P. Komashenko; PRIKLADNAYA MEKHANIKA, No 1, Jan 86)..... 106

Rotation of Symmetric Solid Body in Medium With Square-Law Resistance About Stationary Point
(V.A. Kuryakov; PRIKLADNAYA MEKHANIKA, No 1, Jan 86)..... 107

MECHANICS OF SOLIDS

Propagation of Nonaxisymmetric Elastic Waves Through Isotropic Multilayer Cylinder
(A.Ya. Grigorenko, T.L. Yefimova; PRIKLADNAYA MEKHANIKA, No 1, Jan 86)..... 108

Nonlinear Characteristics of Wave Propagation Through Solid Bodies With Initial Stresses
(O.I. Gushcha, F.G. Makhort; PRIKLADNAYA MEKHANIKA, No 1, Jan 86)..... 109

Deformation and Fracture of Plate Under Thermal Shock
(V.N. Aptukov, A.A. Pozdeyev; DOKLADY AKADEMII NAUK SSSR, No 1, Jan 86)..... 109

TESTING AND MATERIALS

Cryostat for Nuclear Demagnetization and High-Performance Cryostat for Dissolving ^3He in ^4He
(A.S. Borovik-Romanov, Yu.M. Bunkov, et al.; PRIBORY I TEKHNIKA EKSPERIMENTA, No 3, May-Jun 85)..... 111

Pulsed Source of Carbon Plasma for Technological Applications
(A.I. Maslov, G.K. Dmitriyev, et al.; PRIBORY I TEKHNIKA EKSPERIMENTA, No 3, May-Jun 85)..... 113

Two Modes of Plastic Deformation in Glassy Polymers
(E.F. Oleynik, S.N. Rudnev, et al.; DOKLADY AKADEMII NAUK SSSR, No 1, Jan 86)..... 114

Electron Work Function of Metal Surfaces Covered With Adsorbate Atoms and Two-Dimensional Structure of Adsorbate Layer
(L.A. Rudnitskiy; DOKLADY AKADEMII NAUK SSSR, No 1, Jan 86)..... 115

Photolytic Electron Transfer Through Bilayer Lipid Membrane With Quinones as Electron Carriers
(Ye.Ye. Yablonskaya, Ye.I. Klabunovskiy, et al.; DOKLADY AKADEMII NAUK SSSR, No 1, Jan 86)..... 116

/9835

COMPARISON OF VVER-440, VVER-1000 NUCLEAR POWER PLANTS

Budapest ENERGIA ES ATOMTECHNIKA in Hungarian No 1, Jan 86 pp 1-6

[Article by Dr Gabor Bede, university docent, Heat and Systems Technology Institute, Budapest Technical University: "VVER-440; VVER-1000... An Attempt At Comparison"]

[Text] The VVER-440 and VVER-1000 reactor blocks developed in the Soviet Union are the bases for the nuclear energy development plans of the CEMA countries. Earlier plans prescribed construction of the VVER-440 installations and present thinking prescribes construction of VVER-1000 type nuclear power plant units. (According to our present information about 40 VVER-440 type nuclear power plant units will operate in the CEMA countries; one cannot yet estimate today the total volume of VVER-1000 type blocks to be built.) Since the VVER-440 is the result of a long development and the VVER-1000 is--so far--the last station on the same road it seems useful to compare the two systems, at least in a general way, to one another and to the solutions used in other types with similar performance.

Development and Characteristics of the Equipment Used

Reactor development for Soviet energetics began in practice at the end of the 1940's. The first big achievement was the 5 MW commercial nuclear power plant block which went into operation in Obnyinsk in 1954; it was built with a graphite moderator, water boiling reactor. (This was the world's first nuclear power plant for commercial purposes, although not the first reactor block to produce electric power, for this was the EBR-II fast reactor system in the United States.) The further stations of the Obnyinsk development were the energetics blocks at Byeloyarsk and construction of the RBMK type nuclear power plant units recently begun and now under way.

Not even in the Soviet Union (nor in the United States, the other country developing reactors) did the development of water neutron slowing medium energetics reactors get started in the direction of "dry land" applications. The first more significantly powerful energetics units appeared with the pressurized water, thermic reactor system used on the Lenin "atom powered" icebreaker in the Soviet Union. (It appears that less significance was given to boiling reactor development work; the results of it are just now being used, in Gorkiy and Voronyezh, in the AST-500 heat providing systems developed

from the VK-50 basic type.) The development of commercial water-water energetics blocks can be followed most simply via the blocks of the Novo-Voronyezh Nuclear Power Plant. (The water-water energetics reactor is identical, in regard to the Soviet VVER type, with the systems designated pressurized water or, elsewhere, PWR. We will use both designations in the text.)

We summarize in Table 1 the most important characteristics of the primary and secondary cycle--for the blocks in the Novo-Voronyezh Nuclear Power Plant and for newer ideas. It can be seen from the table that both the VVER-440 and VVER-1000 systems are the result of a deliberate development. The manufacturable dimensions of the reactor container determined the value of the primary cycle pressure which could be used, that is the largest permissible temperature of the cooling medium. The fuel is a type developed earlier, only the number of elements used in the heating element changes.

Some Data on the Development of the VVER Reactor Type

	VVER-210	VVER-365	VVER-440	VVER-1000
Electric output capability, MW	210	365	440	1,000
Primary cycle pressure, bar	100	105	125	160
Temperature of cooling water on entering reactor, Celsius	252	252	268	289
Warming of cooling water in reactor zone, Celsius	21	28	33	33
Cooling water flow in primary cycle, cubic m per hour	36,500	49,500	42,000	80,000
Number of cooling cycles	6	8	6	4
Diameter of reactor container, m	3.8	3.84	3.84	4.5
Height of reactor container, m	11.14	11.80	11.80	10.85
Corresponding reactor zone:				
diameter	2.88	2.5	3.2	3.2
height	2.5	2.5	2.5	3.5
Diameter of fuel rods, mm	10.2	9.1	9.1	9.1
number in one heating element	90	126	126	331
Number of heating elements in zone	343	349	349	151
Number of control rods in zone	37	73	37	109
Average output density in zone kW per cubic dm	46	80	83	111
Maximum fissionable material enrichment, percent	2.0	3.0	3.6	4.4
Maximum burn level, MW day/kgU	13	27	28.6	40
Boron control	none	created later	has, but not used	has
Gate valves in cooling cycles	6 x 2	8 x 2	6 x 2	none
Method of maintaining volume equalizing pressure	gas	steam	steam	steam
Steam generator type	horizontal	horizontal	horizontal	horizontal
Number of turbines	3	4 1	2	2 or 1
output capability, MW	70	70 80	220	500 1,000

The most important change between the VVER-440 and VVER-1000 types is to be sought in the formation of the control rods. Ending with the VVER-440 the outer dimensions of the control rods are the same as the outer dimensions of the heating elements; in the VVER-1000--as in the solution used in other PWR types--"clustered" control rod groups are used, a solution which makes possible a zone height-length saving in the height direction in the reactor container.

The change in the formation of the control rod is accompanied by a disappearance of the outer, rigid wall of the heating element. Additional consequences followed from these two circumstances. Let us look at these in a little more detail.

1. The method of control rod formation--up to the VVER-440 type--results in a control rod with external geometric dimensions identical with the fuel. Pulling from the reactor zone a control rod of the same size as the fuel substantially changes the fuel/slowing medium ratio at that place, the number of extra fissions caused by the significant thermic neutron flux increase resulting from this would lead to an impermissible output increase in the region of the "water hole" created. Eliminating the "water hole" is the solution to avoid this; and the optimal procedure for this purpose is "extending" the control rod with fuel. Such a selection of a control rod-fuel combination gives a minimal length of the reactor container three times the reactor zone.

The identity of the dimensions of the control rod and the fuel makes it possible to turn the fuel, having a hexagonal cross section, any number of 60 degree angles during zone reloading without hindering the total loading of the zone. (If the control rods are introduced in amongst the fuel, as in other types of first generation PWR reactors, the fuel elements can be loaded into the zone only in definite positions during zone reloading.) As long as zone reloading cannot be pefectly automated this procedure is the only possible method. It is a circumstance of similar importance that regulator organs placed in amongst the fuel make necessary the manufacture of asymmetrical fuel elements, which further complicates the programming of zone reloading. (Certain fuel elements could be placed only in certain places!) Control rods of the same size as the fuel or the extension then used also require use of guide tubes under the reactor--to eliminate vibration caused by the flow of the cooling medium. The flow moderating effect of the guide tubes is very favorable (as in the systems used in wind tunnels); but this results in an increase in the amount of material to be built in.

2. As a result of fuel element formation with a hermetic wall to the cooling medium, the same cooling medium mass flow takes place along the entire length in each fuel element. This circumstance makes possible a so-called thermohydraulic dimensioning to the hot channel; that is, in the course of the thermotechnic analysis it is not necessary to know precisely the output density distribution; it is true that in this case the omissions made in the direction of safety result in significantly oversize solutions.

3. An "insensivity" to the turning of the fuel elements can be achieved, if we want to improve the solution, so that the control rod (or rods) must be placed in the fuel element, but it is possible to move them only in the symmetrical axis of the element. This requirement can be satisfied with the "clustered" control rods built into the fuel element and used in the VVER-1000 and other second generation PWR power plant blocks. Since the material of the control rod is strongly neutron absorbent the control rod is to be formed with a large surface/volume ratio. This requires a sheet or small radius cylinder--tube--formation, but the mechanical requirements arising in the course of a control rod drop necessary to attain fast shutdowns requires a similar cross section! But if we build the control rods into the fuel elements care must be taken that, during reloading, it should be possible to ensure a subcritical zone in every case even without control rods; this can be realized easily with the already developed boron reactivity control.

4. The hermetic wall to the cooling medium ensuring the mechanical unity of the fuel element becomes unnecessary with use of the "clustered" type control rod system, because then the guide tubes of the small diameter absorptive rods are sufficient to ensure the mechanical unity of the heating element. The ability to leave out the heating element covering not only means a decrease in extra neutron absorption (this decreases the amount of fissionable material to be used!), but also that cooling medium flow and mixing not controlled from outside comes into being among fuel elements with different thermal loads. (The greater warming of the cooling medium arising at places with greater thermal load results in greater volume changes and greater flow speed, and this creates greater local "dynamic" pressure, that is, in the case of the same "total pressure" it creates smaller "static" pressure, which results in a "cross flow" of the liquid--the water.) It can be seen that in this case the dimensioning of the hot channel must be based on a very large number of measurement results (one must know the mixing relationships precisely); thus a more complicated analysis--which can be mastered with computerized methods--is unavoidable in order to analyse the cooling relationships of each fuel rod. The fuel element without a hermetic wall well serves the development of cooling medium mass flow corresponding to the distribution of the fission density, thus--from the strictly thermohydraulic viewpoint--it aids the development of an average value for the cooling medium temperature as it leaves the zone. The new fuel element type certainly saves an increase in reactor container length corresponding to the height of the zone (and this is the case in fact); the reactor container of the VVER-1000 contains nothing "downward" but the structures below the reactor zone and a minimal amount of equipment necessary for other reasons. In addition the nonhermetic heating element covering is also advantageous under breakdown conditions (see below). As a result of the greater U-235 enrichment used in the fuel elements one can achieve a greater burnout level, and the volumetric output density increases. The increase in size of the fuel elements--together with the "clustered" control rod design--results in a more even output distribution. And the dimensions of the active zone are closer to the neutron physics optimum than in the case of the VVER-440.

The VVER-1000 type energetics block uses four primary cooling cycles as opposed to the six cooling cycles of the VVER-440. The reason for the change is obvious: The fewer the cooling cycles the less stainless steel surface to be built in (meaning greater corrosion and radiation safety). We will return to an analysis of the safety of the solutions.

It is worth noting the development of views pertaining to the ability to isolate the reactor cooling cycles, in the case of both the VVER-440 and the VVER-1000:

--The priority of an isolatable cooling cycle was based primarily on doubts pertaining to the availability of the steam generator. It appears that the observations of those who wanted to reduce damage due to an accidental cold start of the isolated cooling cycle correctly prevailed, because it is "simpler" to repair an entire reactor system, when shut down, and after suitable preparations, than to repair an individual subsystem, but with an immediate time limit.

--The VVER-440 units in Hungary do not permit isolation of the cooling cycles, nor is there a possibility in the VVER-1000 units for a separate isolation of the cooling cycles.

The pressure maintaining system for volume equalization is based on steam cushion pressure, instead of the gas cushion pressure used in the first types. Maintaining pressure with a steam cushion is a solution long used in other systems (for example in central heating systems), and it is better suited to operation of the primary cycle than the gas cushion version. (Let us note only as an example that in the case of steam cushion pressure control a reduction in pressure can be solved very simply by changing the condensation state, with water sprayed in from the cold line of the cooling cycle; the pressure of the cold cooling cycle line is greater than the pressure in the volume equalizer by a value corresponding to at least the total pressure drop of the reactor container so, ultimately, the primary cycle can always use its own medium.)

Today the number of turbines used in the secondary cycle belongs primarily among the problems of availability. In the course of technological development, however, the situation was determined primarily by the size of the largest turbine which could be built in at the time. It can be said as a rough estimate that the cycle efficiency of PWR type nuclear power plants is about half the cycle efficiency values for modern conventional power plants. The differences deriving from this in the steam flow--processed in the turbine--result in the fact that, again ignoring a number of factors, the number of low pressure housings for turbines used in PWR nuclear power plants double compared to conventional power plant steam turbines of the same output. It also follows from the foregoing train of thought that--from the design viewpoint--a nuclear power plant steam turbine can be compared with a conventional steam turbine of roughly twice the output. At the time of the development of the VVER-440 the greatest output capability of turbine types used in Europe was 500-600 MW (there were larger capacity machines, but not

yet in series manufacture), so the 220 MW saturated steam turbine used then could not be regarded as not being modern. In the VVER-1000 type block which can be regarded as most developed they use a single 1,000 MW capacity steam turbine. (It could be compared to a conventional machine with a capacity of 1,800-2,000 MW, which is the "peak" today!)

We must also talk separately about the steam generators used in the VVER type nuclear power plants. The nuclear power plant steam generator--a water heated steam boiler--can be compared most simply with the steam transformer formerly used in conventional energetics:

--In regard to its design a steam transformer can have horizontal or vertical heating tubes. The former type can be characterized by less surface (and volume) steam output, but by simpler maintenance conditions and fewer corrosion problems. The latter appears to be "more developed" but maintaining it is more difficult and it is more sensitive to corrosion on the secondary side. (This can be seen simply--there is always under-cooled liquid in the bottom of the vertical heating pipes so even with the best water preparation the remnant contamination condenses here.)

--The horizontal arrangement for a steam generator appears to be the "conservative" solution, and the vertical arrangement "more modern." (One can get greater capacity in the same space.) The space requirement--in base area--is smaller, the moisture content of the steam produced is lower (and can be reduced more easily too) and a number of other advantages could be listed.

Thus far they have used horizontal arrangement steam generators in the Soviet developed VVER nuclear power plants while they use vertical arrangement equipment in the Western PWR nuclear power plants (with the exception of a few "zero generation" systems). It is true that the primary cycle of a PWR planned with a vertical steam generator requires less space. (Or appears to! We will return to a discussion of safety questions.) The fewer steam generators needed is more "elegant" and it results in a pipe schema and primary cycle design easier to review. But let us look at a few other factors based on actual data:

--The most developed type of vertical arrangement is the forced flow steam generator developed by the American firm Babcock and Wilcox. The system can be characterized by really very advantageous operational properties. It is also suitable for production of superheated steam. (One cannot overestimate the advantages of this--from the viewpoint of the turbine.) But, the consequences of the serious breakdown which took place in the TMI-2 nuclear power plant block would have been substantially reduced if the heat capacity of the secondary cycle which could be used in the event of a breakdown had been greater. (There was practically no water available to draw off heat in the forced flow steam generator because of the stopped secondary cycle.)

--The water level height of the vertical arrangement, natural flow steam generators is at least 10 meters. This means that at the lowest level of the secondary side the pressure of the liquid is at least 1 bar greater than the saturation pressure--the fact of under-cooling given. In the Western type PWR nuclear power plants the cause of very many breakdowns recently has been stress corrosion, the cause of the failure of the pipes fixed to the lower

pipe wall of the steam generators. The explanation of the phenomenon is obvious: All the contaminating materials collect in the under-cooled liquid, the use of rolled pipes in the flat wall during manufacture results in quite large remnant stress.

--The larger amount of equipment deriving from the fact that smaller specific steam output can be used in horizontal arrangement steam generators or the larger individual apparatus volumes also mean a greater secondary cycle water volume; this heat capacity can be used very well in a serious situation.

--The present "model illness" of the vertical type steam generators can be regarded as even theoretically excluded because of the geometric formation of the horizontal equipment.

Thoughts About Evaluating Safety

At the beginning of the building of the VVER-440 type blocks in the Soviet Union the nuclear safety thinking--in the area of dimensioning basic assumptions--started from the idea that there was no possibility that a primary cycle line larger than 100 mm diameter should suffer an instantaneous break where the ends of the broken pipe would also shift sideways. It followed from this presumption that in most VVER-440 block reactor buildings the total volume of the so-called hermetical area is about 10,000 cubic meters, which by the above hypothesis is sufficient for reliable isolation from the environment of the primary cycle cooling medium flowing out of the break surfaces--and the energy and radioactivity released. Excluding the possibility of a break in large diameter lines also appears in the standard VVER-440 plans in that the splitting sheet safety ventilation openings of the hermetic area system opening to the environment open outward at an over pressure of 4 bar. (We will not talk here about the technical solutions for reducing pressure in the hermetic system--spraying in water--because we consider the basic principles more important.)

In the course of construction of the Finnish VVER-440 block in Loviisa, on the basis of safety considerations long applied in Western countries, the entire primary system--including the hermetic part--was placed in a hermetic container with a volume of about 60,000 cubic meters. The increase in volume in the hermetic system caused by this outer safety container "makes it possible" to hypothesize even a break in the largest diameter primary cycle pipeline. (More precisely, the dimensioning basic assumption is an instantaneous break in one of the primary cycle cooling water lines and in the cold branch, where it enters the reactor, whatever the cross section of the two breaks, and the consequences thereof.)

A solution deviating from the Finnish one was used in our country in the blocks of the Paks Nuclear Power Plant. As is well known, here, deviating from the standard plans, the hermetic system was developed at the lower level of the reactor building and with the aid of a large cross section tunnel it was linked with a hermetic area beside the building with a volume of about 40,000 cubic meters, so the total hermetic volume increases to approximately 60,000 cubic meters. Obviously the development of the above system was a first step toward uniform application of the basic assumptions of the nuclear safety

judgment, since adopted at the international level. But the question arises: Is this solution really entirely new? In order to answer the question we should review--very roughly--the outside safety container systems used in the world:

--The systems used in Loviisa are also used in PWR nuclear power plants. The variants are: spherical containers made of steel; double walled containers (steel lined reinforced concrete); and the heat withdrawal system in the container can vary (spraying in water, storing large masses of ice, etc.).

--The systems used in BWR nuclear power plants differ from the foregoing primarily in that the strictly interpreted hermetic area is separated from the area of the outer safety container by a water trap through which only the medium can bubble on--obviously in gaseous form.

--In the Canadian heavy water nuclear power plants (for example, Pickering) the role of external safety container is played by a single container with a volume of about 60,000 cubic meters linked with the hermetic area systems of all reactor blocks by large cross section tunnels and kept under a slight vacuum; in the event of an accident the liberated medium can flow into this by opening splitting doors; spraying in water serves to withdraw heat. (A further development of this solution is the system figuring in the plans for the Bruce nuclear power plant in which the water goes, possibly under pressure, from a large volume water tank in the upper part of the container figuring in the typical PWR solution into a pipe system spraying into the hermetic areas.)

If we think about the above it can be easily seen that the solution used at Paks is a combination, block by block, of the BWR systems and the systems used in Canada.

The VVER-1000 reactor block is made with the external safety container used in the PWR nuclear power plants, thus applying completely the guide design principle adopted at the international level. In addition, the container can be made in versions resisting aircraft impact and earthquake--following from the requirements system which has become more detailed in the meantime, in contrast to the domestic buildings of the VVER-440 which do not meet these requirements.

But a study of the circumstances of pipe break type accidents cannot be limited to external safety containers alone; the heat withdrawal that can be attained in the primary cycle is of crucial importance in an analysis of possible releases. The consequences of a cold branch break would develop almost identically with the VVER-440 and VVER-1000 type reactors. It would be possible to avoid a drying out of the zone only by operating the breakdown cooling system. The situation would be slightly different in the case of a hot branch break or larger volume flow taking place elsewhere; the primary cycle volumes of the two types are not in proportion to the ratio of the outputs (the output ratio is more than double with a volume ratio of only 1.2-1.3). In the case of the VVER-440 the volume of the primary cycle contains a relatively large quantity of water so as long as the reactor zone remains under water cooling could be ensured even in the event of a breakdown (this is also well served by the fact that in order to aid the cooling necessary during zone

reloading the steam generators are so placed that they are suitable for withdrawing heat at such times also). This circumstance can also explain the fact that the high pressure breakdown cooling system goes into operation at--relatively--lower pressure (60 bar). (But this was not the design justification (!) because, as we said, during safety design of this type they were still assuming only small diameter pipe breaks.) The smaller relative water quantity used in the VVER-1000 type--as is general in PWR primary cycles--certainly justifies the use of a (really) high pressure zone cooling system. (For this reason the primary cycle contains a "supplementary" container, also called a "breakdown boron solution storage" container, which is connected directly into the reactor or into the cold cooling water branch.)

And finally the availability of a nuclear power plant is a sort of safety question, the safety of the providing of power. Comparing the two units raises the question of single block construction and twin block construction. It is a fact that the two turbine-one reactor solution is unique in world nuclear power plant construction. There is no adequate base for a comparison of availability, for it is well known that operating data on the VVER-1000 blocks are not yet sufficient to prepare statistics which are precise enough, and the VVER-440 block cannot be compared with foreign data.

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REGULATION OF HIGH-FREQUENCY CHARACTERISTICS OF LINEAR ELECTRON ACCELERATOR

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 6, Nov-Dec 85
(manuscript received 10 Jul 84) pp 23-26

[Article by A.N. Filatov and V.K. Shilov]

[Abstract] A linear electron accelerator with tunable coupling cells in its structure is described, such cells allowing regulation of the buncher characteristics without opening the enclosure and additional hookup. There are two axial coupling cells here, one a prismatic resonator excited in the TE^{0}_{101}-mode with two sliding ("tuneable") choke plungers and the other a cylindrical resonator, in addition to the bunching cells and the accelerating cells. Power to the accelerator cells is fed from a high-frequency voltage generator. This arrangement, adopted in the RELUS-3 standing-wave electron accelerator, allows regulation of either the accelerator current at fixed optimum electron acceleration or of the output energy at fixed accelerator current. Figures 4; references 2: 1 Russian, 1 Western.

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LINEAR INDUCTIVE ACCELERATOR

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 6, Nov-Dec 85
(manuscript received 1 Oct 84) pp 19-23

[Article by V.V. Vasilyev, G.G. Kanayev and E.G. Furman, Scientific Research Institute of Nuclear Physics, Tomsk Polytechnic Institute]

[Abstract] A linear inductive accelerator capable of accelerating charged particles to high energy levels over short distances (on the order of several MeV/m) with relatively low voltage and high efficiency requires large

ferromagnetic cores and a high switching power as well as a low-impendance pulse generator. A scheme of such an accelerator has been developed which not only simplifies its layout but also reduces its size and weight. The following elements are located together in a single housing: a circular multichannel spark-gap discharger; two stacks of wound (3 turns) ferromagnetic cores, one for injection and the other for acceleration with a device for magnetizing the cores; an inductive pulse generator four consisting of strip shaping twin-lines bent into an Archimedes spiral outside the coils; and apparatus for shaping and transporting the electron beam. A field-emission cathode with voltage induced by the injector current serves as electron source for the accelerator. For performance control, a relation has been established between the energy of injected electrons and the current in the first accelerator section. On this basis it is to generate 1-2 kA pulses of 60 ns duration by injection of a 0.2-0.4 MeV electron beam with a 200-400 kV cathode voltage and a charging voltage of 60 kV across the shaping twin-lines will ensure a 550 keV increase in electron beam energy. Figures 4; references 8: 7 Russian, 1 Western.

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COMMENTARY ON SIBERIAN OILFIELD EQUIPMENT SUPPLY PROBLEMS

Moscow SOVETSKAYA ROSSIYA in Russian 9 Jan 86 pp 1, 2

[Unattributed commentary under the rubric "Report from the Field": "Following the patterns of yesteryear"; concluding paragraph in boldface]

[Text] At a conference of the Tyumen and Tomsk Oblast party and economic aktiv on 6 September 1985, M.S. Gorbachev spoke of the need for technological retooling in the oil-production industry. He stressed particularly that on account of the low quality and poor reliability of everything connected with the oil-production industry, some very serious questions would be asked of all individuals in positions of responsibility. It was decided to convert most of the wells in Western Siberia to mechanized production methods and to furnish them with efficient and reliable equipment as a matter of urgency. How are the machine-builders coping with this challenge? Our correspondents have filed the following reports.

The Megionneft oil and gas production administration was for many years one of the best in the business. But more recently the collective there has been consistently missing its deadlines. What is going wrong?

"Equipment used in mechanized oil production should work without a hitch," A Rudolf, a foreman, commented. "But here, because of unscheduled shutdowns of submersible electric pumps, for example, 116 wells are presently closed for repairs."

It has come to light that the workmanship of the equipment being delivered to the oil-fields frequently fails to meet operating requirements. Approximately 14 percent of the submersible electric pumps and sucker-rod pumps produced by enterprises under the supervision of Minkhimmash [Ministry of Chemical and Petroleum Machine Building] have proved to be defective. One in five machines and mechanical devices designed for well overhaul was found to deviate from the standard technical specifications. Items sent to the oil-fields by enterprises under the supervision of the Soyuzneftemash All-Union Production Association, and in particular the Almetevskiy Submersible Electric Pump Plant, which is run by the Soyuzneftekhimmash All-Union Production Association, came in for more criticism than most. What do the manufacturers themselves think about this?

"The oil-men are simply too picky," A. Proshechkin, Director of the Almetevskiy plant, declared. "If they find a couple of bolts missing, they'll fire off a complaint straight away..."

To hear it said, you might think that bolts are a superfluous detail which one really does not need to do the job. But if the recipient of a submersible electric pump fails to spot something amiss in his set-up, the pump may go out of commission all of a sudden, way below ground level. It then has to be removed from the well and repaired at the oil-production association's base. Minnefteprom [Ministry of the Oil Industry] has established a special subsection which does nothing but recheck newly delivered pumps.

"It's the only way to go about it," explained A. Naboyshchikov, Chief Engineer at Minnefteprom's central production maintenance base for submersible electric pumps, which is in Almetevsk. "It is simpler and easier to rectify a plant defect here than out in the oil-field, under field conditions."

And there are plenty of defects. In Tyumen Oblast alone, more than eight thousand individuals have been relieved of their basic production duties and transferred to quality control. If oil equipment manufacturing quality does not pick up during the 12th Five-Year Plan period, then the number of specialists in Western Siberia assigned to checking and repairing equipment that is on its way to the oilfields will have to be increased 1.5-fold.

Complaints about output quality do not stop this same Almetevskiy plant from blithely reporting the successful fulfilment of its plan targets. Taking advantage of its role as a supplier of hard-to-get items, the plant management compels the oil-men to take whatever is to hand. If, for instance, they are offered standard installations instead of the corrosion-resistant items they want, no arguments come from the oil-fields. It is that or nothing...

The oil producers have some serious complaints about equipment design standards. The basic equipment, the blueprints for which are drawn up by Minkhimmash's Azinmash Institute [AzSSR Scientific Research Institute of Petroleum Machine Building], where the Ministry's development engineering is done, is inferior--in metal content, reliability, mechanization standards, and completeness on delivery--to its higher-end competitors. And yet, if world-class equipment were to be delivered to the oil-fields, there would be fewer repairs and fewer temporary well closures, and the country would have more oil. While the designers are aware that this is an important approach, the technical designs which are being produced have yet to show any sign of it. For example, pumping, acidizing and washing installations have not changed in the slightest over the past 12 years. What is preventing the creation of new and progressive lines?

There is in Moscow a bureau for the design, study and introduction of rodless pumps, which works for the Ministry of Chemical and Petroleum Machine Building. Its main purpose is to create prototype equipment which is responsive to the highest operational requirements. Regrettably, it cannot

yet be said that the work there has speeded up at all. It takes five whole years to create an installation that incorporates diaphragm pumps or reciprocating hydraulic pumps!

"Our laboratory lacks some basic equipment," B. Kartashev, Deputy Director of the Electrical Equipment Division said by way of justification.

"We create our prototypes using apparatus which is twenty years old," E. Protas, Designer in Chief in the Centrifugal Pump Division, volunteered. "Not to mince words, we are putting complex devices together with...hammers. To speed up the work, we need modern test-beds with microprocessors, computer technology, computer-aided design..."

The laboratory we visited was indeed extremely ill-equipped. TThe specialists feel that it is high time to set up a specialized inter-departmental research and production association which would take charge of all aspects of oil-production equipment manufacture. Such a step would ultimately cut down the time spent on the development and introduction of modern equipment. [by] B. BALKAREY, M. ZARIPOV (special correspondents)

As can be seen from our correspondents' reports, the equipment supply to the oil-fields as yet leaves much to be desired. What are the responsible departments doing to bring about definite improvements in this state of affairs? The editorial office posed this question to senior officials in Minnefteprom and Minkhimmash.

V. DINKOV, Minister for the Oil Industry:

Jointly with nine other ministries, including Minkhimmash, Minelektrotekhprom [Ministry of the Electrical Engineering Industry and Electrical Power Machine Building], and Minpribor [Ministry of Instrument Making, Automation Equipment and Control Systems], we have drawn up and ratified 39 programs for the 12th Five Year Plan period. They contain provisions for the development of new types of equipment and for the enhancement of manufacturing quality. For certain extremely important kinds of oil equipment--submersible centrifugal pumps, screw pumps, electrical pumps, and sucker-rod pumps--a substantial lengthening of mean time between failure has been stipulated. New acceptance arrangements for equipment dispatched to the oil-fields are to be instituted from 1 January. Representatives of the USSR State Standards Committee will perform the inspections.

A. RUTSKOY, First Deputy Minister for Chemical and Petroleum Machine Building:

Production assignments for branch organizations and enterprises have been formulated in accordance with a comprehensive development agenda drawn up for the oil and gas industry in Western Siberia for 1986 through 1900. Our designers have been instructed to speed up the development of technical documentation for a state-of-the-art gas-lift compressor station, which will use the kind of gas turbine engines found on airplanes. To step up oil production, we will be manufacturing the Soviet Union's first hydraulic piston pumps. Other innovations are also on the drawing board. To improve

spare parts delivery to the enterprises, we are teaming with Minnefteprom to plan the establishment of support centers in Surgut, Nizhnevartovsk and other towns in Western Siberia, which will always have a good supply of the necessary assemblies and components in stock. It is our intention that the accelerated delivery of new equipment, including complete submersible centrifugal electric pump installations, will provide the groundwork for more stable working conditions out in the oil-fields during the new Five Y ar Plan period.

The soothing and encouraging tone of the answers given by the two senior ministry officials should mislead no one. We say again that the technological backwardness of a significant share of oil industry equipment and the unsatisfactory quality of deliveries today constitute a formidable obstacle to the fulfilment of plan targets for the recovery of a crucial raw material. What we need are not verbal assurances of measures in hand and "bright" prospects, but prompt and practical action, a palpable improvement in the status quo. Regrettably, do not yet detect enough of this attitude in the statements of Minnefteprom and Minkhimmash.

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GEOLOGICAL PRODUCTION STATION IN THE 12th FIVE-YEAR PLAN

Moscow NEFTYANOYE KHOZYAYSTVO in Russian No 2, Feb 86 pp 40-41

[Article "Geological Production Station in the 12th Five-Year Plan" under the rubric "On the Way to Accelerating Scientific-Technical Progress"]

[Text] A basic task confronting the oil and gas industry in the 12th Five-Year Plan is to significantly increase the efficiency of exploration and labor productivity during drilling.

Improvements in drilling equipment, methodology and information-processing computer equipment have given rise to a new trend in automating drilling and geological monitoring: creation of automated systems to collect and process geological-geophysical and technical information during drilling. Use of these systems makes it possible, by means of comprehensive information on the drilling solution, slurry, core, and drilling conditions, to do geological and process monitoring, immediately solve geological problems in identifying productive seams and zones of anomalously high layer pressure lithological analysis of a cross section, and production tasks in optimizing well drilling.

In 1985 "Geofizpribor" MPO [Interdepartmental Production Association] produced the first lot of SGT [geological production] stations, the first model in a series of geological production research stations.

The SGT station is intended to carry out gas mapping and production studies during drilling for gas and oil. It has primary information sensors (based on SKUB [not further identified]) and data collection and processing apparatus. Slurry is analyzed using a luminoscope. The station permits analog and digital recording of more than 40 parameters, including load on the catch and on the bit, turntable torque, torque on the machine wrench, pressure in the feed line, drilling solution flow rate at inlet, change in solution flow rate at outlet, level and change in the amount of drilling solution in receiving tanks, drilling solution temperature, etc.

During mechanical and gas mapping, the station records drilling parameters in analog form on KSP recorders and indexes them in digital form to appropriate displays. The scales of analog depth recording are 1:200 and 1:500, in increments of 0.5 and 1.0 with respect to the analog recording depth.

The station is housed in a KUNG-P4 van (see illustration) [not reproduced].

In 1987-88 the SGT station will be the basis for geological production research systems with expanded capabilities--the SGT-2 and-3,--which will use a new method to measure depths, record a larger number of parameters, and do more processing. The station will be augmented by geological instruments; it will be more comfortable and have a larger cabin.

The next step in developing and producing a series of geological production research stations is creation of computerized SGTK-1 and -2 stations. These stations will provide automated information collection, in-depth analysis of geological parameters, drilling process optimization using software, and output on command of various reports, references, etc.

In the 12th Five-Year Plan, to reduce time for development and series assimilation of SGTs and for delivery to organizations in Minnefteprom [Ministry for the Petroleum Industry], Mingeo USSR [Ministry for Geology], and Mingazprom [Ministry for the Gas Industry], "Geofizpribor" MPO is developing stations with functional modules. Design continuity is ensured in the modifications, functions are being gradually expanded, and characteristics of subsequent station modifications are being improved by developing and perfecting new modules. Personnel are being trained to operate these stations.

Successfully carrying out the entire set of organizational and technical measures for SGT stations will make it possible to accelerate well drilling by 15-20%.

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THE USE OF FUEL AND WATER EMULSIONS IN SHIPBOARD DIESEL INSTALLATIONS

Leningrad SUDOSTROYENIYE in Russian No 7, Jul 85 pp 18-22

[Article by Yu.I. Vorzhev, and K.K. Gimbutis]

[Text] At the present time, the use of water and fuel emulsions based on motor and diesel fuels for shipboard power plants is considered as one of the directions for expanding resources and saving motor fuels; therefore, this paper can be of interest for a wide circle of marine engineers.

Under the conditions of high prices for fuel together with the search for alternative forms of it, great importance is being acquired by measures directed at increasing the efficiency of DVS [internal combustion engines] by improving the combustion process and mixture formation with a simultaneous reduction of the smokiness and toxicity of exhaust gases in accordance with the requirements for preserving the environment. In this connection it seems advisable to investigate what possibilities are opened up in the use of water-fuel emulsions in diesels for the purpose of increasing their efficiency. This method attracts the attention of researchers and operators by the simplicity of the formulation and also by the possibility of solving a number of other serious problems; namely, the reduction of carbonization, the smokiness and toxicity of exhaust gases, and lowering the noise level.

It is known that the presence of water in fuel in a free state leads to reduced reliability of the operation of the fuel equipment. This is connected with the fact that globules of water falling into the clearances of the precision pairs of parts in the fuel equipment bring about their corrosion and subsequent jamming. If it is seawater, then, because of its high salinity, the speed of corrosion increases. In addition, the presence of sodium salts in seawater reduces the temperature for vanadium corrosion in turbosuperchargers and exhaust valves. With regard for what is set forth hereinafter, the water-fuel emulsions considered are those in which fresh water is in an emulsified state.

A water-fuel emulsion is a colloidal system consisting of two mutually insoluble liquids, one of which is the dispersed phase (water) in the form of minute droplets uniformly distributed in the other - the dispersion medium (fuel). The stability of a water-fuel emulsion is determined by the kinetic (the property of dispersed particles to be retained in suspended condition) and the unit stability (the ability of dispersed particles to resist enlargement by merging with each other).

Kinetic stability depends on the dimensions of the dispersed phase and the difference of the density of the phase and the medium. With a reduction of both factors, stability is increased. Unit stability is achieved as a result of the formation on the exterior surface of the droplet (that is, on the border of the interface of the phase) of a capillary colloidal adsorption (solvate) layer - the emulsifying agent (stabilizer of the emulsion) - which prevents the merging of the droplets (Ref. 1). Thus, the surface of all droplets (globules) of water is covered with a solvate layer on the surface of which a layer of fuel is disposed. The solvate layer limits the action of the force of cohesion. This, as was indicated above, not only contributes to the unit stability of the emulsion, but it also prevents contact of free water with the surfaces of the metal parts of the fuel equipment, preventing their corrosion. This is the principal difference between emulsified water and free water. Heavy residual fuels contain natural emulsion stabilizers in their make up; namely, asphaltic tarry substances. The preparation of water-fuel emulsions based on these fuels does not bring about difficulties.
The preparation of water-fuel emulsions based on distillate fuels, for instance diesel fuel, is practically impossible without an emulsifying agent. For the latter, various surfactants are used.

The selection of these substances for stabilizing emulsions is a complicated engineering problem since the content of the emulsifying agent must be minimal to avoid carbon deposits and costly water-fuel emulsions. In addition, the emulsifying agent must not be toxic or corrosive.

The period of existence of a water-fuel emulsion based on diesel fuel without an emulsifying agent and with a water content of from 5 to 20 percent at a temperature of 20 C, amounts to from 17 to 4 minutes respectively. It is possible, however, to obtain a more stable emulsion based on diesel fuel by the addition to it of an insignificant quantity (up to 5-10 percent) of residual fuel which, as indicated above, contains natural stabilizers of emulsions.

It is necessary to emphasize that the stability of a water-fuel emulsion, depending on the size of the water particles and the quantity of surfactant in the fuel, is determined by the existence of equality of the surfaces of the dispersed phase and the surfactant. In a case when the total surface of the dispersed water is larger than the total surface of surfactant:

$$(\Sigma F_{H_2O} > \Sigma F_{ПАВ})$$

the emulsion is unstable, and a partial merging of water globules is observed. Consequently, the quantity of surfactant in the fuel is the limiting factor

for the dispersion of the water. These conclusions have been confirmed by experiments. Thus, a water-fuel emulsion based on F-5 residual fuel containing 4 percent asphalts with an 8 percent water concentration and water globule size of 2-5 micrometers (Figure 1,a) obtained in a flap homogenizer at a pressure of 30 MPa, is unstable. For the first 32 hours, a partial growth merging of water droplets is observed. Later, the emulsion stabilizes. One would conclude that the droplets not having a solvate layer had merged. With a 10-15 micrometer size of water globules (Figure 1,b) the water-fuel emulsion was stable up to 3 months.

Of the physical-chemistry characteristics of water-fuel emulsions, it is necessary to note the viscosity, temperature of congelation, and surface tension. With an increase in water concentration, the viscosity of a water-fuel emulsion is increased. This contributes to the appearance of so-called structural viscosity. The difference between the viscosity of a water-fuel emulsion and unwatered fuel is a maximum at temperatures in the area of 0-20 C and a minimum (practically coincident viscosities) at temperature values of 85-95 C. But, for heating the water-fuel emulsion up to this temperature corresponding to optimum viscosity, additional heat is required. For example, for a water-fuel emulsion based on residual fuel F-5 with 18 percent watering, the additional heat amounts to 35-40 kJoules/ton.

The congelation temperature of a water-fuel emulsion is increased by 8 C in a 10 percent watering of F-5 residual fuel. It must be supposed that the increase in the congelation temperature promotes dispersal of the centers for the crystalization of the paraffins during the turbulization of the water-fuel emulsion.

The surface tension of a water-fuel emulsion is insignificantly increased. For an emulsion prepared on a base of F-5 residual fuel with a concentration of water from 10-20 percent, the surface tension is increased by 5.4-10.8 percent respectively by comparison with unwatered residual fuel. With an increase in temperature, however, this difference is reduced.

Two variants may be encountered in the preparation of a water-fuel emulsion and its use in shipboard power plants:

- from a coarsely dispersed emulsion prepare a finely dispersed one,
- prepare an emulsion with the measuring out of a specified amount of water.

The manufacture of emulsions according to the first variant is encountered in the process of using it in boiler plants during the burning of peroleum residues.

The preparation of emulsions according to the second variant is typical for systems of diesel power plants and requires adhering to these conditions:

- water introduced must be preliminarily dispersed, and

- during the introduction of the water, the residual fuel must be heated until a viscosity of $38\text{-}53 \cdot 10^{-6}$ m^2/second is achieved.

The preparation of water-fuel emulsions is carried out in various kinds of homogenizers, dispersers, and ultrasonic and other apparatus where intensive actions are possible which create turbulent motion of the fuel and water. The use of these apparatuses has been brought about by the striving to obtain the minimum size of the water globules in the emulsion. Their action is based on the principle of the disintegration of the liquids into thin directed layers or streams, and on the principle of the drawing out the dispersion phase into thin threads with subsequent breaking of them into fine particles, and also on the effect of cavitation during an oscillation of pressure over a great range.

Mechanical mixers, in agitating fuel and water, create relatively low turbulence. In proportion to the growth in demands for the homogeneity or dispersivity of emulsions, homogenizers began to stand out. They permit obtaining emulsions with a high degree of dispersivity. In those cases when the necessity arose to emphasize that the mixing be accompanied by the shattering of a stream of one liquid in another for fine droplets, the mechanisms carrying out such an operation began to be called dispersers. In this, the desire of researchers to achieve the maximum degree of the dispersion of water and the use for this purpose of complex and energy consumptive apparatuses, is not always justified. Contributing to this are affirmations frequently encountered in the technical literature to the effect that the water globules in an emulsion during its preparation should be 3-5 micrometers in size. Those sizes unquestionably are too low. Investigations conducted by the authors show that gear-type and regenerative-turbine pumps which yield 10-15 micrometer water globules are fully acceptable for preparing water-fuel emulsions.

Considering the process of preparing water-fuel emulsions, one cannot lose sight of the fact that the dispersion of the water and its intensive mixing are continued in the high pressure pump and injector section (Ref. 2). As a result of the pressure changes in the pipeline during the cut-off of fuel by the pump, sections with lowered pressure appear in the pipe during which a periodic vaporization and condensation of the water takes place which leads to its breakup and redistribution volumetrically in the fuel. The final dispersion is carried out by the injector. In so doing, the average size of water globules in the emulsion during its injection into the cylinder of the engine amounts to 3-5 micrometers. It has been established by investigators that the dispersion of the water after the injector depends relatively little on the dispersion of the emulsion ahead of it (Ref. 3).

The process of combustion of a water-fuel emulsion differs from the combustion of unwatered fuel. A droplet of water-fuel emulsion, having a core of one or several droplets of water covered with the solvate layer and fuel, upon injection into the combustion chamber begins to be heated up. At a temperature of 150-200 C, the physical properties of each of the components of

the liquid are changed. The shell of fuel around a droplet remains in liquid state since the boiling point of the fuel (residual fuel) is above 300 C, and the water begins to vaporize. As the droplet is heated, its viscosity and surface tension are lowered and the pressure of the internal water vapor is increased leading to an increase in the size of the droplet with subsequent cutting of it into fine particles by rupture. This phenomenon has been named "microexplosions". The phenomenon of microexplosions is well illustrated in Figure 2 where the behavior of a droplet of water-fuel emulsion at a pressure of 0.5 MPa and a temperature of 700 C was caught on motion picture film at intervals of 0.01 and 0.02 seconds (Ref. 2).

It has been established that the temperature necessary for the beginning of boiling of the dispersed phase is weakly dependent on the water content of the emulsion; therefore the length of time an emulsion droplet exists before the microexplosion can be considered identical for any concentration (Ref. 4,5).

Thus, the supplementary breakup of the droplet of water-fuel emulsion by the microexplosions increases the surface of evaporation of the fuel and leads to its intensive mixing with the oxygen of the air which contributes to its more complete combustion and reduces the oxides of carbon in the exhaust gases. Along with the intensification of the formation of the mixture, the water vapors actively participate in the chemical reactions of the combustion processes and they contribute to the gasification of carbon, and the loosening of deposits and their burnout. In the combustion of a water-fuel emulsion, part of the heat which is liberated in the exothermic reactions, is expended in vaporizing the water, as a result of which, exhaust gas temperatures are lowered.

Thw water concentration in the emulsion for each type of engine, depending on the design of the combustion chamber, speed, fuel used, and so on, has an optimal value with which the maximum reduction of the specific fuel consumption is achieved. Analysis of tests conducted on 25 engines of various designs with the use of both diesel and heavy fuels, showed that in the majority of cases maximum economy is achieved with a water concentration in the emulsion of 10-20 percent (Figure 3). In addition, for each magnitude of the power or loading of an engine there exists an optimum water content in the water-fuel emulsion. With an increase of it above the optimum, efficiency is reduced. This can be explained by the excess expenditure of heat on vaporizing water above that improvement of the process of mixing and combustion which the emulsion gives. An hypothesis on the maximum possible size of the fuel saving in the use of a water-fuel emulsion can be made on the basis of an analysis of the heat balance of an engine. Considering that the remainder term of the equation of the heat balance of a shipboard diesel amounts, on the average, to 1-8 percent (Ref. 6) a substantial portion of which is determined by incomplete combustion of fuel, it is possible to expect that the magnitude of the fuel saving also will be found to be within those limits (see Figure 3).

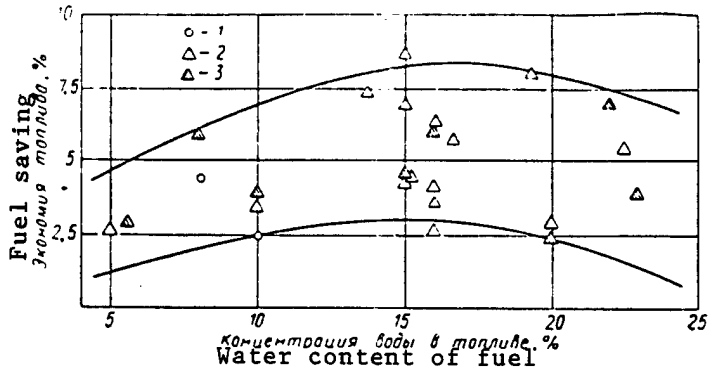

Figure 3. Maximum fuel savings achieved on engines of different design.
1 - diesel with a separate combustion chamber, 2 - diesel with unseparated combustion chamber, running on light fuel, 3 - the same, running on heavy fuel.

The further improvement of the process of fuel preparation led to the appearance of systems for preparing water-fuel emulsions which provide for the emulsification directly in the fuel flow by using standard devices for fuel preparation for an engine. The components of the water-fuel emulsion are stored separately from one another and, in a suitable technology for the preparation of water-fuel emulsions, its homogenization and stability are provided for without the use of expensive surfactants. The fitting of them with automatic metering devices for the water and the control of its actual concentration depending on the engine loading, permits obtaining the maximum gain from fuel savings, and reduces expenditures for reequipping systems for fuel preparation or for manufacturing them anew.

Thus, an analysis of results of tests of systems for the preparation of water-fuel emulsions in shipboard diesel power plants permits defining the basic requirements for them as follows:

1. Systems must provide for a high homogeneity and stability of a water-fuel emulsion which excludes the possiblity of the merging of the droplets of liquid and the settling-out of the fine particles on the whole path of the delivery of the emulsion from its preparation to its burning in the diesel's combustion chamber.

2. It is recommended that the size of the water droplets (globules) in a water-fuel emulsion ahead of the injector be in the range of 5 micrometers.

3. The capability must be realized of automatically regulating the amount of water fed in and maintaining its amount at the optimum level in the water-fuel emulsion depending on the loading of the engine.

4. The magnitude of the viscosity of the water-fuel emulsion fed into the cylinder also must be maintained at optimum level.

5. The separation of the fuel and water during their filtration in fine filters must be ruled out.

6. A reliable, simple and quick change-over of a diesel operating on a water-fuel emulsion to the operation of it on pure fuel, and vice versa, should be provided.

7. The systems should have devices for monitoring the actual water concentration in the water-fuel emulsion.

In the Litovsk Maritime Shipping Company, systems for the preparation of unstabilized water-fuel emulsions based on residual and diesel fuels have been developed and tested. The system (Figure 4,a [Figure 4 not available]) is for main engines and diesel generators having fuel booster pumps of the regenerative-turbine or geared types. Fresh water from a tank 3 is led through valve 4 and filter 5 to a reducing valve 6 which lowers the pressure to 0.2 MPa after which is is fed to the metering valve 7. The latter regulates manually or automatically the amount of water delivered, depending on the loading of the engine. In the case of using the valve with manual regulation, the operation of the system is possible only for a sustained invariable engine power. In the case of the use of the automatic metering valve, the amount of water fed in over the range from maximum to minimum power is regulated by the pressure of the supercharging air or by means of an automatic system determining the fuel consumption of the engine.

This system consists of two sensors. One sensor of the position of the fuel rack produces a signal proportional to the fuel fed in for one revolution of the shaft (q). The second sensor sends a signal proportional to the frequency of rotation (n). Both these signals are fed into a multiplier and later, before delivery to the regulating valve, are amplified. Thus, the output signal after the multiplier represents the fuel consumption per unit time, $Q = qn$. For diesel generators, control by an automatic metering valve can be simplified. Considering that the power of the generator corresponds to the power of the diesel, it is sufficient to use the signal of a sensor which determines a change in the loading of the generator (the magnitude of the current). In addition, the control of the automatic metering valve can be done by the fuel rack, considering that the diesels in the complex with the generators operate according to the loading characteristic ($n = \text{const.}$). Either of these signals are fed along the lines of connection 9, 10 to the panel of control and signalling 11, after which, along line 8, it is fed into the automatic metering valve 7. Control of the quantities of water being delivered is determined by the rotameter 12.

Passing the measurement stage, the water is fed through electromagnetic valve 14 to a hydrodynamic disperser 15 with a constant speed of discharge. The devices described - the water filter, reduction valve, automatic metering valve, rotameter, and the panel of control and signalling - are mounted in a single unit - a module. The electromagnetic valve 14 is a back-up element controlled by the metering valve 7 through the electrical line of connection 13. In reaching the minimum power of 0.4 of rated power, characteristic in maneuvering, the automatic metering valve is automatically cut off and, at the

same time, closure of the electromagnetic valve takes place. The purpose of the hydrodynamic disperser 15 consists in preliminary dispersion of the water and the uniform distribution of the globules of it into the flow of fuel in pipeline 1 which connects the fuel service tank 2 with the booster pump in which the second dispersion of the water takes place. The indicated technological sequence of dispersing the water is decisive for the preparation of finely dispersed, stable, water-fuel emulsions. Passing pump 24, the prepared water-fuel emulsion is fed through heater 23 and filter 22 to the high-pressure pumps 18 and along the high-pressure pipelines 17 to the injectors of the diesel. Fuel from the high-pressure pumps, after cut-off, is returned along pipelines 19 and 21 to the intake manifold of the booster pump and repeatedly dispersed. It is necessary to note that with the prospect of the use of residual fuels with a temperature of heating above 100 C, the installation of a deaerator in the line for cut-off fuel ahead of the booster pump is probably necessary in this system.

In Figure 4,b a diagram is shown of a universal system which can be used for all types of diesels operating on both residual and diesel fuels. This system is similar to the preceding, the only difference being that in the module, in addition to the elements for metering and preparing the water, there is a disperser 15 with electromagnetic valve 14 and emulsifier 16 with an electric drive. A GK-1 cavitation generator can be used as the emulsifier.

Besides that, the sensor of the regulator of the temperature of heating the fuel in heat/exchanger 23 is installed so that the temperature of heating the water-fuel emulsion is maintained at the optimum level. Cut-off fuel from the high-pressure pumps 18 is led out along pipelines 19 and 21 into the main fuel line beyond filters; and a one-way valve, installed in pipeline 19 rules out the stagnation of the cut-off fuel in the pipeline and the possible loss of stability of the emulsion.

In the use of this system for engines operating on water-fuel emulsions based on diesel fuel, the heater 23 can be excluded from the system. And in the case where the module is situated at a considerable distance from the high pressure fuel pumps, it is recommended that a cavitator 20 be introduced supplementarily directly ahead of the high-pressure pumps. For the drive of the cavitator, the energy of the flow of fuel is used. While preparing water-fuel emulsions based on medium viscosity fuel or mixtures of it, the cavitator can be excluded from the system.

Operational tests of the system of Figure 4,a were carried out on the 2,180-ton deadweight Yunyy Partizan class dry cargo ships Marat Kozlov and Vanya Kovalev fitted with 8 DRN 36/60 (8 TAD 36 Sulzer) main engines having a power of 1,500 kW at 300 rpm, the fuel preparation systems of which included fuel booster pumps of the regenerative-turbine type. The high-pressure fuel pumps of these diesels are of the valve type with timing according to the beginning of injection. Water metering was carried out within the limits of 0-30 percent for the purpose of determining its optimum value. The magnitude of carbon formation was determined on cylinder and piston assemblies

and on control plates installed in the exhaust tract. The wear on parts of the cylinder and piston assemblies was established by the method of spectral analysis of lubricating oil taken from the wall of a cylinder (Ref. 7). Residual fuel F-5 and M-20 was used in the engine.

Three-month tests and subsequent 1.5-year operation of the named ships showed that the proposed system provides high-quality preparation of an emulsion and guarantees its stability, and provides also for reliable operation of the engine. In this, according to numerous measurements, the dependence of the mean statistical value of the fuel saving on the concentration of water in it at a power corresponding to 80-90 percent of rated power, was established (Figure 5).

The maximum value of the fuel saving of 4.2 percent was achieved with an 18 percent water concentration in the fuel. The reduction of carbon deposits on parts of the cylinder and piston assembly and the exhaust tract amounted to 43 percent. This is explained by the improvement of the atomization of the fuel, by the completeness of its combustion, and by the gasification of sooty deposits. The carbon deposits were changed in quality. They became looser, more porous and easier to remove. The sootiness of the exhaust was substantially reduced. The clogging with coke of injectors was absent. This permitted increasing the time between motor cleanings from 4,000 hours to 7,000 hours which, however, is the limit. The temperature of the exhaust gases was reduced in proportion to the increase in the concentration of water in the water-fuel emulsion (Figure 5) because of the consumption of heat in vaporizing the water. The magnitude of the wear on parts of the cylinder and piston assembly is practically unchanged. [Figure 5 on following page.]

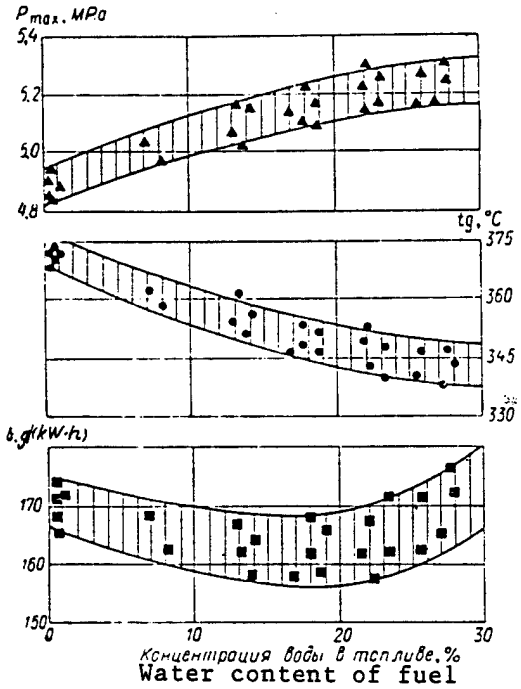

Figure 5. The dependence of cycle parameters on the water content in the water-fuel emulsion for the 8 TAD-36 engine.
b- is the specific fuel consumption, tg- is the exhaust gas temperature, Pmax- is the maximum combustion pressure.

In addition, on the 3,930-ton deadweight timber carrier Lyuban experimental investigations were carried out of the operation of the type 5 ChN 20.5/30 (the 520 MTVN 30 Burmeister and Wain engine) auxiliary diesel generator having a power N = 184 kW at a speed of n = 600 rpm, operating on a fuel mixture of 30 percent M-20 residual fuel and 70 percent diesel fuel. The character of the progress of the working process is shown in Figure 6,a . The water concentration was varied in the range 0-20 percent. [Figure 6 on following page.]

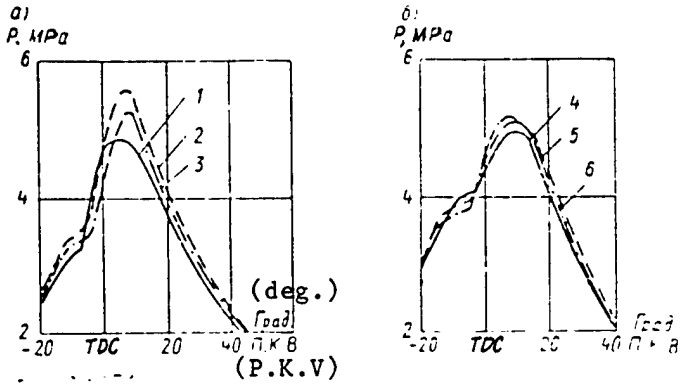

Figure 6. Indicator diagrams from the Burmeister and Wain diesel type 520 MTVN 30.
a)- operating on a water-fuel emulsion with a water content of: 1 - 0%, 2 - 10%, 3 - 20%; and b)- diagrams from a Sulzer diesel type 8 TAD-36 operating on water-fuel emulsions with water contents of: 4 - 0%, 5 - 18%, 6 - 20%.

P. K. V. is the angle of rotation of crank shaft.

As a result of the investigations, it was established that a maximum fuel saving of 4.08 percent at 90 percent of rated power was obtained with a water concentration in the water-fuel emulsion of 15 percent. The amount of carbon deposits was reduced by a factor of almost 2. The temperature of exhaust gases in all conditions of loading was lowered by approximately 15 C.

A statistical analysis of indicator diagrams recorded by oscillograph shows that with an increase in the concentration of water in the water-fuel emulsion, there is an increased delay in self-ignition. This is explained by the loss of heat to vaporizing the water; and the superheating of its vapor contributes to a reduction of the temperature in the combustion chamber at the beginning of injection of the water-fuel emulsion. Thus, the time for self-ignition of the fuel is increased. As a result, before ignition much fuel accumulates in the cylinder. Later on, this quantity of fuel, in the presence of the water vapor, burns more intensely increasing the maximum combustion pressure Pmax (see Figure 5). The vertex of the diagram (see Figure 6) is insignificantly shifted in relation to top dead center. Meanwhile, the direction of its shift was conditioned by the design features of the high-pressure fuel pumps of the engine. For pumps timed by the beginning of injection, with an increase of water concentration in the emuslion, Pmax is shifted to the left toward top dead center (see Figure 6,b). For pumps timed by the end of injection, the opposite phenomenon takes place (see Figure 6,a).

The indicated changes in the working process are insignificant and do not require supplementary regulation of the fuel equipment. The lowering of the temperature of the exhaust gases in the burning of a water-fuel emulsion in

the engine leads to a corresponding drop in the temperature in the cylinder in the intake stroke and the possibility of increasing the air charge which increases the pressure of compression (see Figure 6).

It is necessary to turn attention to the fact that with increased water content in a water-fuel emulsion, the rpm of the engine is slightly reduced. Meanwhile, the all-regime governor does not restore the initial value. This is explained by discrepancies in the regulating characteristics of the governor; that is, by the noncorrespondence occuring between the centrifugal forces of the governor-weights and the rigidity of the spring applied to the fuel pump rack during operation on a water-fuel emulsion.

Analysis of the investigations conducted permit formulating the following conclusions.

- systems for preparing a water-fuel emulsion having double dispersion; that is, with dispersion in a hydrodynamic disperser and in the booster pump, and which exclude tanks for its storage and which use the hydrodynamic characteristics of the systems, are reliable and assure high homogeneity and stability of a water-fuel emulsion,

- to obtain the maximum fuel saving, the amount of water fed in varies with the loading on the engine,

- the achieved gain from the use of water-fuel emulsions at the current level of knowledge can be explained by the phenomena of microexplosions of the emulsion, by the improvement of mixture formation, by the dissociation of water vapors, and by their participation in the gasification of sooty deposits. This is confirmed by the reduction of fuel consumption, by the reduction of carbon deposits and of losses from chemically incomplete burning,

- water injected into a cylinder in the form of an emulsion contributes to lowering the temperature of the cycle and the parts of the cylinder and piston assembly which, in the final analysis, influences the kinetics of the transformation of the products of combustion and the reduction of the concentration of the most ecologically dangerous oxides of nitrogen, NOx,

- the use of simple and reliable systems for the preparation of unstabilized water-fuel emulsions is an effective means of increasing the efficiency of diesels and of reducing carbon deposits and heat stress levels,

- the use of water-fuel emulsions can be considered as a realization of the possibility of using heavier fuels in marine diesel power plants and a realization of an expansion of resources and fuel conservation.

PHOTO CAPTIONS

1. p 18 Figure 1. The appearance of a water-fuel emulsion during preparation: a- by an homogenizer of the flap type, b- by a fuel booster pump of the regenerative-turbine type.

2. p 19 Figure 2. The appearance of water-fuel emulsion droplets inserted into a medium with a temperature of 700 C and a pressure of 0.5 MPa after: a- 0, b- 0.01, and c- 0.02 second (Ref. 2).

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UDC 629.12.037.11.001.24:539.4

STRESS CHARACTERISTICS OF SHIP PROPELLERS WITH SCIMITAR BLADES

Leningrad SUDOSTROYENIYE in Russian No 10, Oct 85 pp 8-11

[Article by I.A. Titov, L.I. Vishnevskiy, V.M. Zaznobin and I.I. Sizov]

[Abstract] The main advantage of a ship propeller with scimitar blades is the low level of vibrations transmitted from it to the ship hull, as much as 80 percent less than with conventional propellers; however, the much higher stresses produced in scimitar blades also lower their reliability. According to statistical data, torsional stresses from hydromechanical forces cause 95% of all failures on any ship. Extensive systematic computer-aided stress analysis by very effective methods such as finite elements, accounting for the load distribution over the span as well as over the chord, has revealed that the geometry of a scimitar blade is responsible for high stresses in the blade material, their magnitude depending essentially on the curvature of the median line along the blade profile. Blades with a scimitar angle larger than 15-20° are most vulnerable, particularly during reversing, when stresses in these blades become up to 4 times higher than in conventional ones. Possible remedies are use of high-strength blade materials and reduction of the propeller speed without change of blade dimensions, or reduction of the blade diameter with corresponding buildup of the blade thickness with retention of the optimum thickness-to-chord ratio. A favorable factor in such a redesign is that the hydromechanical bending moment and the drag torque are proportional to the linear dimension and to the linear dimension cubed respectively. The design of scimitar blades requires special rather than conventional methods of distributing the load, also special criteria for material selection to ensure manufacturability as well as adequate strength and stability in operation.

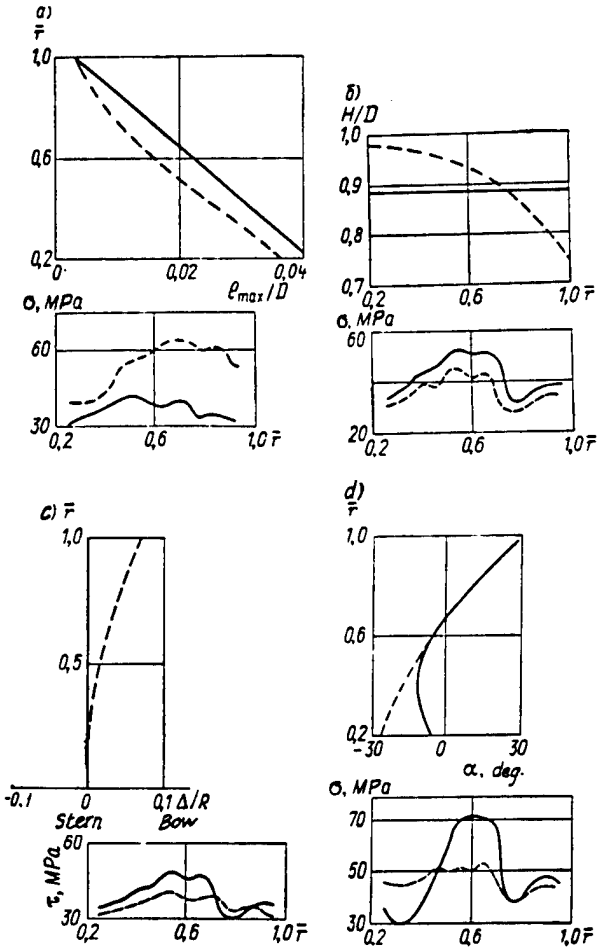

Figure 2. Dependence of distribution of maximum principal stresses (σ) along radius ($\bar{r}$) of propeller screw on geometry of blade: (a) change of thickness e_{max}; (b) change of pitch ratio H/D; (c) change of relative blade throwback Δ/R; (d) change of scimitar angle α corresponding to curvature of median line along blade profile; ——— propeller with scimitar blades; ----- conventional propeller.

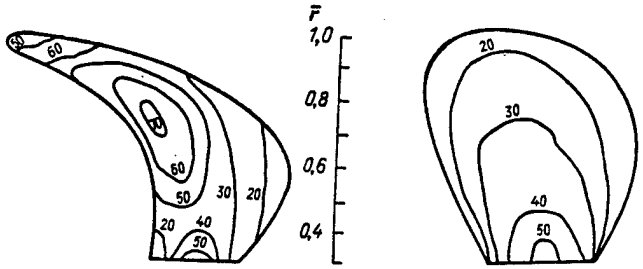

Figure 3. Distribution of principal stresses on pressure side of scimitar blade and of conventional blade under same engine thrust. Numbers denote stresses in MPa.

Figures 7; references 5: 1 Russian, 4 Western.

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EFFECT OF WINDMILLING INLET DEVICES ON PERFORMANCE OF SHIP COMPRESSORS AND FANS

Leningrad SUDOSTROYENIYE in Russian No 10, Oct 85 pp 20-21

[Article by V.L. Zhokhov]

[Abstract] In connection with the recent trend toward use of axial compressors and fans with gas turbines or other engines and as superchargers for high-head boilers on ships, a freely rotating inlet device is known to appreciably widen the range of stable operation without stalls and surges. In an experimental study made for the purpose of determining the effect of such a device on the performance characteristics of an axial compressor stage, a windmilling wheel with an array of guide vanes made of sheet steel was mounted on the compressor shaft. Its vanes had a biconvex profile making the wheel behave as two rigidly coupled ones, a compressor in front and a turbine behind, rotating at the same speed on a common shaft but in the direction opposite to that of the runner of the axial main compressor stage. Tests were performed in a wind tunnel with the air velocity varied over the N_M = 0.1-0.12 range of the Mach number, with the compressor speed varied over the 12.5-16.6 rps range and with the Reynolds number varying over the $N_R = (1.8\text{-}2.0)\cdot 10^5$ range. Two windmilling wheels were tested, with the curvature of the guide vanes different in each so as to make the ratio of circumferential velocity to absolute air stream velocity equal to 0.3 and to 0.5 respectively. For comparison, tests were also performed without a windmilling wheel and with a conventional array of inlet guide vanes with a "solid body" profile. The results indicate that a windmilling wheel as inlet device shifts the stability limit of an axial compressor, or fan, toward lower flow rates and reduces the speed of separation zones.

A windmilling wheel designed with a larger curvature of vanes for a higher circumferential velocity was found to be more effective. Plugging the wheel at low flow rates may further improve the compressor stability and braking it at intermediate flow rates may ensure nonseparation flow around the compressor blades.

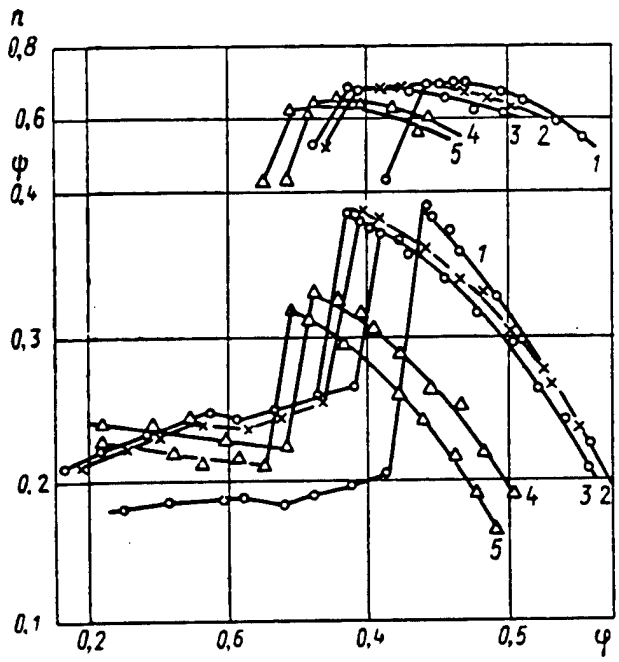

Figure 3. Overall characteristics of compressor stage:

1- stage without inlet guide vanes
2- stage with windmilling inlet guide vanes AVNA-1 (radius of curvature R = 71.34 mm)
3- stage with windmilling inlet guide vanes AVNA-2 (radius of curvature R = 45.83 mm)
4- stage with plugged windmilling inlet guide vanes AVNA-1
5- stage with plugged windmilling inlet guide vanes AVNA-2

Figures 4; tables 2.

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SELECTION OF OPTIMUM TEMPERATURE DIFFERENCE IN DESIGN OF AIR COOLING SYSTEMS

Leningrad SUDOSTROYENIYE in Russian No 12, Dec 85 pp 11-12

[Article by A.G. Ionov, V.N. Erlikhman and A.E. Suslov]

[Abstract] A method of designing a refrigeration plant with screw compressors for holds on fishing vessels is outlined, taking into account that the ratio of cooler surface area to hold volume varies from ship to ship over a range as wide as 0.1-0.4 m^2/m^3 and correspondingly will also vary the temperature difference between hold air and boiling refrigerant. With the coefficient of performance stipulated and with the air temperaturesin the hold as well as the outboard water temperature given, selection of the optimum temperature drop across condenser, air cooler, and evaporator is based on the economic criterion of total annual plant operating cost as minimizable target function. This method is applied to refrigeration plants operating with grade-R22 fluid and with constant condensation pressure, for reliable fluid feed without use of pumps. Calculations based on conventional performance, design, and cost formulas for each plant component reveal that the optimum temperature difference between hold air and boiling R22 fluid is 5-7°C for any ship. This is less than the 10°C temperature difference usually selected for refrigeration plants with compressors of other types. Figures 1; tables 1; references 3 (Russian).

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THIN-FILM OIL COOLER

Leningrad SUDOSTROYENIYE in Russian No 12, Dec 85 pp 13-15

[Article by Ye.V. Glubokov]

[Abstract] A thin-film heat exchanger has been developed for cooling engine oil, a liquid most difficult to cool with a heat transfer coefficient in conventional coolers not exceeding 4000 $W/(m^2 \cdot K)$. It consists of several self-positioning disks mounted on a shaft between each disk a sectioned hollow hydraulic chamber with a tapered gap separating them. When the shaft rotates, viscous friction with the rotating disks draws the hot oil into the tapered gap, forming 20-80 μm thick films. At the same time, cold water is passed through the chambers and carries away the heat from those oil films. The flow of oil through the gaps raises the pressure head which drives the oil from the heat exchange zone through taps to the oil pan for recirculation as lubricant; in this way the exchanger also acts as an oil

pump. The design of this heat exchanger is based on theoretical relations and experimental data describing its performance characteristics as a pump an as an analog of a slipper or Kingsbury thrust bearing, and the dependence of its regrigeration on the tangential velocity of the disks, thermal characteristics of the "bearing cushion", and flow rate of the cooling water. Its vibration level is 20-30 dB lower than that of a conventional electric oil pump. A heat transfer coefficient of 6000-7000 $W/(m^2 \cdot K)$ is feasible, which is 10-12 times more refrigeration than attainable with tubular heat exchangers. It can operate with or without a housing and thus can be placed anywhere, particularly in a crankcase or a gear-box. Figures 5; tables 1.

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SUPERHARD MATERIALS FOR AXIAL BEARINGS

Leningrad SUDOSTROYENIYE in Russian No 12, Dec 85 pp 17-18

[Article by G.A. Gunbin, Ye.O. Bryanskaya and S.M. Gavrilov]

[Abstract] In the manufacture of axial ball bearings it is desirable to coat the active surfaces of bearing components with a superhard carbide. Bearing shoes, balls, and thrust plate are usually made of a high-strength steel (11Cr18Mo, 40CrNiAl, chromium ball bearing ShKh15) and tungsten carbide is preferred as coating material because of its superhigh wear resistance as well as high thermal and chemical stability along with a relatively high thermal conductivity. The feasibility of coating deposition by the ion sputtering process was evaluated on bearing components subsequently checked for surface roughness and tested for wear over a period of 20 hours at a rotating speed of 120 rpm with reversals after every 7 revolutions. Plain tungsten carbide (WC) as well as a combination of tungsten carbide and a cobalt-base (VK15) binder were used as coating material, from targets prepared for this purpose by methods of the powder-metal technology. The results indicate that bearing shoes wear fastest and, therefore, are the critical bearing component, while 40CrNiAl steel is the best material for the thrust plate. They also reveal that a coating of the WC+VK15 composite material is better, because of its plasticity even at room temperature. Figures 3; references 3: 2 Russian, 1 Western.

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CSO: 1861/141

UDC 621.311.24.01.46

SUPPORT COLUMN OF REINFORCED CONCRETE FOR MEGAWATT WIND POWER PLANT

Moscow BETON I ZHELEZOBETON in Russian No 2, Feb 86 pp 20-21

[Article by K.Z. Galustov, candidate of technical sciences, O.L. Perfilov, engineer, and A.B. Pavlov, engineer, All-Union Planning, Surveying, and Scientific Research Institute of Hydraulic Engineering Equipment and Structures imeni S.Ya. Zhuk]

[Abstract] Two rotary wind power plants with two pairs of vanes at different levels on a vertical shaft have been evaluated and found feasible for operation in the USSR, a 15 MW plant and a 1 MW plant. The support column for the 15 MW plant is a cantilever hollow cylindrical structure of reinforced one-piece M500 concrete rising from a foundation plate underground. The reinforcement consists of unstressed class A-III steel rods 20-40 mm in diameter and 36 prestressed bundles of K-7 steel ropes 15 mm in diameter grouped into 12 bundles of 3 running through vertical ducts in the concrete lined with polyethylene tubes. The required compression and correspondingly the required number of bundles decreased toward the top of the structure, and tension is applied at the lower ends, beneath the foundation plate. An anticorrosion lubricant is injected into the ducts, thus the high-strength bundles make no contact with the concrete except at the anchoring points. The support column has been designed for long life, taking into account creep of concrete in accordance with the nonlinear two-component theory which covers aging and aftereffect buildup of irreversible strains as two independent factors. The possibility was considered that creep of concrete could cause the tensile stress in steel to increase as much as threefold and the resulting overall stress redistribution would reduce the compression of concrete so as to cause cracking unrelated to operating conditions. Calculations were based on applicable Construction Norms and Regulations II-21-75 formulas for axial hoop compression, this method giving an up to 10% larger margin than the general method. The initial state of stress and strain under a compression load was evaluated according to the linear theory of elasticity, by the method of finite differences. The safety factor for the most highly stressed column section was calculated. Figures 3; references 4 (Russian).

2415/9835
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UDC 666.973.004.8

EXPERIENCE WITH USE OF FLY ASH FOR PRODUCTION OF CONCRETE MIXES

Moscow BETON I ZHELEZOBETON in Russian No 2, Feb 86 pp 39-40

[Article by Ye.V. Luzhko, engineer, I.I. Zadolinnyy, engineer and V.A. Safarov, engineer, 'Stroyindustriya' [Construction Industry] Office of Design and Manufacturing Engineering, L'vov coordinating department]

[Abstract] Production processes have been designed for concrete manufacturing plants in the UkSSR which will use fly ash from thermal electric power plants in the concrete mix. Some have already been installed and are operating successfully in several Reinforced-Concrete Products Manufacturing Plants and Housing Construction Combines (L'vov, Rozdol, Kalush, Vinnitsa, Zhitomir). Ash is delivered by railroad in hopper cars, unloaded pneumatically into moisture-proof underground bunkers, then driven by compressed air through pipes up to a distributor. From here it is dropped into silos at the bottoms of which are mounted jet pumps driving the ash via a common duct to a precipitator and then a cyclone separator or set of multicyclone separators on top of the discharge bin. From there it is dropped through a batcher into the concrete mixer. In the Zhitomir plant 100 t/h of ash is driven by air under a pressure of 0.4 MPa from bunkers with a capacity of 60 m^3 to a distributor 35 m above. In the Vinnitsa plant, producing 20,000 m^3 of concrete annually, use of ash saves 600 t of cement annually, installation of the ash delivery system having cost 21,000 rubles. Figures 4.

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UDC 681.3.068

CONTROL OF FLEXIBLE MANUFACTURING SYSTEM MODULES IN TYPICAL SITUATIONS

Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 1, Jan 86 pp 18-19

[Article by V.K. Anikin, engineer, and Candidate of Technical Sciences A.I. Savitskiy]

[Text] The flexibility of modern production is made possible by the ability to rapidly readjust equipment for the production of new products. This is achieved because of the use of reprogrammable industrial robots and multimode and multifunction production process equipment, as well as the employment of computers for controlling all FMS modules--from the simplest equipment to robotic lines.

Changing to a new production process route consists in rearrangement of the structure of the control system, including replacement of some programs by others. In this connection, the principle of the modularity of special software is of particularly great importance. Each software module must possess functional completeness and logical completeness and perform the functions of processing information and/or the formation of control actions. The principle of software modularity, as well as the hierarchical structure of the control system, make it possible to carry out the designing of algorithms and programs with high efficiency within the framework of a computer-aided design system (CAD). As a result, the time it takes to develop software is shortened considerably and costs are lowered.

The FMS includes robotic systems (RTK's), loading and conveying equipment, and other production process equipment united into a robotic line.

Each RTK contains a certain number of robotic cells and a plotting table. The cell includes a robot having cyclic program control. In addition, at each FMS level (the RTK, line and cell levels), production process equipment can be used which is controlled and coordinated by means of the computer of the corresponding level of the FMS SU control system, or controlled by a built-in microprocessor.

The production process is described at each level of the FMS by a sequence diagram, on which are specified the time intervals and the operating sequence of the controlled entities (individual pieces of equipment, production

process modules with built-in microprocessors, cells and systems) belonging to a given level of the FMS control system.

A fragment of a hypothetical sequence diagram for the operation of certain controlled entities belonging to one level of the hierarchy of an FMS, for a specific production process, is illustrated in fig 1. On the sequence diagram it is possible to single out a number of typical situations reflecting the time and logical relationships of individual production process operations. The moments of time for the start, $t_{n.r}$, and end, $t_{k.r}$, of operation represent each operation to be performed by a production process module. At moment $t_{n.r}$ the control program is output from the control system to the controlled entity, and at moment $t_{k.r}$ it is made known to the control system that the controlled entity has completed the execution of a specific production process operation.

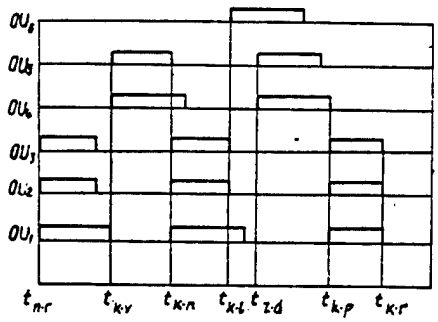

Figure 1. Hypothetical Sequence Diagram

It is possible to distinguish a number of typical situations for completion of a production process route. The first situation is characterized by the fact that all the specified controlled entities (e.g., OU_1, OU_2 and OU_3) finish operation at moment of time $t_{k.v}$. In the second situation a certain controlled entity (e.g., OU_5) concludes operation at moment of time $t_{k.n}$. In the third situation any given number of controlled entities (e.g., two from OU_1, OU_2 and OU_3) conclude their operation at moment of time $t_{k.1}$, and in the fourth some controlled entities (OU_4, OU_5 and OU_6) conclude their operation in a certain sequence (e.g., OU_6, OU_5 and OU_4) as of moment of time $t_{k.p}$.

As can be seen from the sequence diagram, control actions can enter an OU [controlled entity] only in the case of the origin of one of the above-described situations, as well as after some specific delay interval (e.g., at moment of time $t_{z.d}$).

An analysis of the situations cited made it possible to develop a set of standard algorithms and programs making it possible to check the origin of situations and to form control information. The set of standard algorithms includes the following: the AFIR--algorithm for formation of the start of operation of specific OU's; the AFKR--algorithm for forming the end of the operation of specific OU's; the AOKV--algorithm for determination of the end of the operation of all OU's from a specific list; the AOKN--algorithm for determining the end of operation of one OU from a specific list; the AOKL--algorithm for determining the end of operation of any number of OU's from a specific list; the AOKP--algorithm for determining the consecutive end of operation of OU's from a specific list; and the AFTZ--algorithm for formation of a production process delay.

These standard algorthms served as the basis for the development of standard program modules which have been implemented in the ASSEMBLER language for the "Elektronika-60" computer.

The sequence diagram for the operation of an RTK consisting of three cells and a plotting table is illustrated in fig 2. Each robotic cell is designed for the assembly of parts of a single standard size. One operating cycle of the RTK [robotic system] corresponds to the assembly of one part by each cell, which for this purpose successively perform three kinds of work (three sequences of control instructions for the robot and production process equipment). The resulting program for controlling the functioning of a robotic system for the assembly of units made from these parts includes standard program modules (the PFNR, PFKR, POKV, POKN and PFTZ).

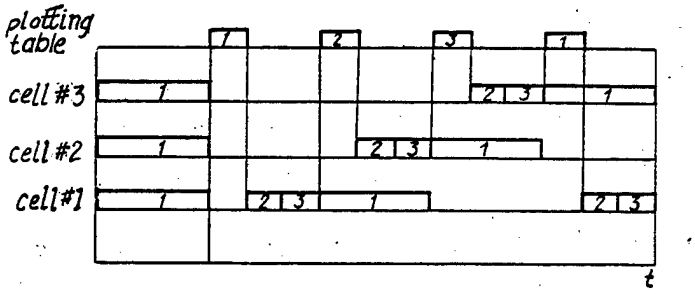

Figure 2. Sequence Diagram for Operation of Robotic System

The set of standard algorithms and programs has been included as part of the software system of a control system for an FMS for the assembly of units at one production association. The universal nature of this set makes it possible to develop control system special software for an extensive class of flexible assembly machine systems whose production processes can be described by means of sequence diagrams.

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MANUFACTURING PROCESS PLANNING IN SPINNING OF SHELL-TYPE PARTS ON NC MACHINE TOOLS

Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 1, Jan 86 pp 21-22

[Article by Candidate of Technical Sciences P.F. Grigoryev and N.Ye. Gayvoronskaya, engineer]

[Text] At the Voroshilovgrad Machine Building Institute a procedure has been developed for designing a production process for automated metal spinning on NC lathes.

Process planning for the production of shell-type parts when using NC machine tools here includes a new important step--the development of control programs.

The development of the production process for the fabrication of shell-type parts on NC machine tools is performed in a definite sequence and consists of the following steps: choice of the type, dimensions and method of producing the starting blanks; determination of the efficient sequence for fabrication of the part (the process route); choice of the model of the NC machine tools and of the method of mounting and fastening the blank in the machine's spindle; determination of the structure of operations and choice of the shaping scheme; the execution of process charts; the choice of available or the designing of new attachments (correlating the paths of the automatic movement of tools with the machine's coordinate system, the staring point for machining and the position of the blank); choice of the type and dimensions of the available or the designing of new spinning or cutting tools; determination of machining modes for all manufacturing steps; and technical standardization of machining, and the performance of comparative economic calculations in the case when several possible alternatives for producing the part have been noted.

The extent of process preparation for production depends on the model and production capabilities of the machine tool, the type of NC system and the presence of the hardware for designing and implementing the program. Generally, process preparation for production in automated spinning of shell-type parts on NC machine tools is performed according to the following scheme: Based on the working drawing of the part and the drawing of the

blank, a special drawing (preferably on millimeter graph paper) is prepared for designing the program; the production process is developed for machining; reference points for the beginning and end of manufacturing steps (the paths of travel of the tools) are indicated on the drawing and the coordinates of these points are computed; a process chart is drawn up, on which the distance between reference points is expressed in the pulses to be transmitted to the motors which set the machine tool's working elements into motion; a chart is drawn up onto which all the data necessary for machining are entered in coded form; the coded information is entered onto the program medium (usually punched tape, and, when necessary, from it onto magnetic tape); a check is made of the correctness of the record on punched tape; the program is debugged; the process for fabricating the part on the machine tool is tried out.

For the purpose of eliminating errors in the programming of the machining process, provision is made for checking the punched tape by various methods (comparing the punched tape with the original table, making two punched tapes for visual comparison, an automatic check by means of plotters, etc.)

A programming step of no small importance is debugging of the program, the purpose of which is to correlate the prepared program with the specific machine tool, blank, tools and attachments, and to check the correctness of the process decisions involving the choice of the machining sequence and the automatic spinning mode, as well as of designer decisions relating to the design of attachments. Debugging of the program is performed in several steps. First it is tried out without setting up the blank, tools and attachments. For the purpose of tracing paths at this stage it is a good idea to use a recorder mounted at the reference point for fastening the tool. Then trial spinning of the part is performed, using the tools and attachments, and complete machining of the test part.

Shell-type parts are produced after the revelation and correction of errors and the appropriate correction and repeated checking of the program.

The introduction of the automated spinning of shell-type parts of a complex combined shape on NC machine tools by using this procedure for process preparation for production at one enterprise in Voroshilovgrad made it possible to gain an annual saving of more than 90,000 rubles.

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DEVELOPMENT AND INTRODUCTION OF CONTROL PROGRAMS FOR OXYGEN CUTTING MACHINES OF 'KRISTALL' TYPE

Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 1, Jan 86
pp 42-43

[Article by A.P. Palnikov and P.A. Davydenko, engineers]

[Text] A plasma-arc cutting process utilizing oxygen cutting machines of the "Kristall" [Crystal] type has been introduced at the Kharkov Hoisting-and-Conveying Machinery Plant imeni Lenin. Two machines have been installed: the model "Kristall-3,2 TPL" with a model ULPI-2 numerical control unit (UChPU) and the model "Kristall-2,5 TPL" with a model LKI numerical control unit.

Experience has been gained in the development and application of appropriate control programs and in the operation of machines of the "Kristall" type. Engineering and process planning for production has been performed at the plant for the purpose of the efficient utilization of these machines. For example, a design has been developed for a table for laying down sheets, as well as for a fume hood, which made it possible to seal all joints to the maximum, which reduced losses of air to a minimum.

The design of the drive for opening and closing the fume hood's air damper made it possible to extend the air duct closing stage, which made restoration possible by opening the exhaust port. The table has detachable frames which can be used on two sides. This lengthens the service life of the table and simplifies its repair and cleaning. Each machine is furnished with an exhaust fan with a capacity of 10,000 m^3/h, and the exhausting of the gases formed in the process of plasma arc cutting is accomplished by opening an exhaust port directly opposite the location of the plasma generator.

Planning of the positioning of the machines was done by allowing for mechanization of the ancillary operations of feeding a sheet and removing finished parts. Both machines are attended to by a single manipulator of the gantry type with a load-lifting capacity of two tons. The structure of the manipulator includes three hoists with arms. Eight electromagnets of the MP-20 type are placed on each arm. The manipulator is controlled from a separate console.

As demonstrated by experience, impact equipment (heavy presses and hammers) must not operate alongside "Kristall" machines, since the accuracy of the machine's work is reduced. The rigidity and precision of the bases on which the guide rails are placed when the machines are assembled also influence the precision of their work.

The plant's chief welder's department's service has put out a request for proposal for the development of control programs in the form of a cutting chart. On it are indicated the position of parts to be cut out, the mechanical trajectory of the cutter, outlines of the parts to be cut out, and also the specifications. The most complete utilization of metal has been provided for in writing the request for proposal. When using standard sheets (8 x 1600 x 6000 mm and 8 x 1800 x 6000 mm, etc.), cutting is performed on the entire sheet, and when using non-standard ones, on part of a sheet (one to four parts). In the latter case the operator repeats the control programs several times for the purpose of cutting out the required number of parts. The amount of switching on and off must be minimal for the purpose of economizing on electrodes.

The control programs for the machines were developed by Ukrorgstankinprom [not further identified]. A post processor has been developed for the model "Kristall-3,2 TPL" oxygen cutting machine with a model ULPI-2 NC unit, and the post processor has been implemented in the FORTRAN algorithmic language for the "Minsk-32" computer, based on a version of the SLDATA language (a processor - post processor intermediate language) for operation with the SAP-FIALKA-M automated control program preparation system. The post processor for the "Kristall-2,5 TPL" machine with a model LKI NC unit was implemented for the YeS-1022 computer.

The post processors form control programs both for the model ULPI-2 and LKI NC units in special codes, and for the model NZZ-1M NC unit in ISO-Ibit code, which makes it possible to make a check of programs on standard equipment.

The programs for the machines are written on five-track paper punched tape. The control programs are checked at the institute on an IKP-1M plotting table, and the mechanical trajectory of the cutter is traced at the plant by means of a special instrument on the sheet, after which the dimensions of the programmed contour are measured. A final check of the programs is made with the parts cut from the sheet.

A library has been created at the plant which contains 220 programs, 158 of which have been tested in operation.

Automation of the development of control programs for oxygen cutting machines of the "Kristall" type has made it possible to reduce the labor intensiveness of the development of programs, to improve their quality, and to shorten the time from development to introduction.

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EFFECTIVENESS OF UTILIZATION OF SUBSTITUTES FOR METAL IN MACHINE BUILDING

Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 1, Jan 86
pp 49-50

[Article by B.V. Senchenko, engineer, and Candidate of Economic Sciences A.V. Kozenko]

[Text] An important factor resulting in efficiency in the use of metal and a reduction in the metal content of machine building products is expansion of the use of substitutes for metal, i.e., plastics, cermets, etc.

The employment of plastics makes it possible to improve the quality of products while at the same time reducing the labor intensiveness, power intensiveness and metal intensiveness of production. The high cost of polymers is compensated by the low consumption of these materials per unit of product and by their great production-process and operating advantages: The use of one ton of plastics in machine building makes it possible to replace on average 3.5 tons of rolled metal, and to lower the cost of machine building production by 1000 to 1500 rubles and operating costs by 300 to 400 rubles. The introduction of plastics is especially effective in those cases when they replace metal parts with a low metal utilization factor.

Machine building is the biggest consumer of plastics. About 30 percent of their total production is consumed as construction materials and for production process needs in the industry. The extent of the consumption of plastics by the Ukrainian SSR's machine building industry in 1984 equaled 61,500 rubles worth, whereby the greatest percentage in the consumption structure is constituted by the electrical equipment industry (76 percent), the instrument making industry (7.2 percent) and the machine tool and tool making industry (3.8 percent).

Of the total consumption of plastics, 60 percent is used for manufacturing machine parts, instruments and production process equipment and containers, and 40 percent for making cable and electrical insulation products and consumer goods.

The use of polymers in machine construction makes it possible to gain a considerable saving: Per 1000 tons of plastics, as a result of reduction of the labor intensiveness of the manufacture of products, up to 500 workers

are freed, and because of a reduction in the amount of metal working and of the metal content of products, about 80 metal-cutting machines, and the consumption of electric power is reduced by 4 million to 5 million kWh. The saving in labor costs and the reduction in the cost of production per one ton of plastic used equal in the machine building industry, respectively, 500 to 1000 man-hours and 1000 to 4000 rubles.

In the structure of the consumption of polymers by kinds, cable flexible PVC constitutes the highest percent (47.9 percent). And 62.4 percent of the total consumption of plastics for cables is by the electrical equipment industry. The group norm for the saving of traditional products as a result of the introduction of plastics for the fabrication of protective sheaths for cables per one ton of cable products (in terms of weight of copper) from lead equals 770 kg, from cable-insulating paper 65 kg, and from rubber 240 kg.

In the electrical equipment industry plastics have become widely used as an insulating material in the manufacture of electrical machines operating at high temperatures and in corrosive environments; and in the manufacture of motors, for making fans and housings for them and terminal boxes. This has made possible a considerable saving of metal, a reduction of labor costs and an increase in the safety level for the operation of motors. By making plastic housings instead of ones formed from sheet steel, a saving of about 1500 tons of steel a year is achieved, and the use of polymer insulation in d.c. electrical machines makes it possible to reduce the consumption of electrical sheet steel by 39 percent, of insulating materials by 26 percent, and the total weight of machines by an average of 22 percent.

Of the total consumption of plastics by the Ukrainian SSR's machine building industry, polyethylene (28.5 percent) and polystyrene (20.3 percent) constitute a considerable percentage.

The production of highly expanded plastics with high physicomechanical and electrical characteristics is promising; the cost of these materials is considerably lower than the cost of ordinary plastics.

The employment of plastics as metal substitutes is being impeded in a number of cases by their high cost, small selection, ageing tendency, and relatively low heat resistance.

The use of powder metallurgy products is very effective for purposes of economizing on metal: Processes such as melting, casting ingots and rolling them are totally eliminated, and the amount of machining is reduced considerably. Each ton of powder replaces on average 2.5 tons of metal. The saving from the substitution of metal parts by ones sintered from iron powder equals 1.75 million rubles, and from nonferrous metal powder, 2.2 million rubles per 1000 tons of powder.

8831
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EDITORIAL URGES ECONOMIZING IN DIE FORGING

Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 2, Feb 86 pp 2-3

[Article: "Improved, Low-Waste Machining Processes for Machinebuilding"]

> [Text] "Provide an increase in national income by increasing the productivity of social labor. Reduce the ...metals-intensiveness of labor by 13-15 percent" "...accelerate the changeover to resources-conserving and waste-free technologies. Significantly improve the use of recycled resources..." (from the draft "Basic Directions of USSR Economic and Social Development in 1986-1990 and up to 2000"). "...-- development of technologies using high pressures, vacuum, pulse effect and explosions to synthesize new, superhard materials, gas- and hydro-extrusion items and contoured sections, shaping and sizing large, complex shaped items..." (from the Comprehensive CEMA Member-Nation Program of Scientific-Technical Progress up to 2000).

The ambitious tasks of developing the national economy and increasing the well-being of the people through the achievements of scientific-technical progress as set forth in the pre-Congress documents have inspired and oriented city and countryside workers towards creative searching for ways of managing thriftily.

In the practical work of machine building enterprises, scientific and engineering achievements have become an essential base for obtaining good results with the least expenditures of material and labor resources. Economizing is becoming the primary source for meeting the additional resources requirements of the national economy. Leading enterprise collectives are working this first year of the new five-year plan under the slogan "Five-Year Plan Assignments Without Increasing Resources." The labor collectives have assumed obligations to work at least two days a year using saved raw material and electric power. Creative activism has ensured success in the search for resources conservation. Thus, enterprises of the Georgian SSR have obligated themselves to save 37,000 tons of rolled metal in 1986, and 80 percent of the increment in production requirements [for it] will be met through conservation. Workers in the Lithuanian SSR will be working using saved raw material on opening day of the 27th Congress and will obtain 50 million rubles in profit through savings for the year.

Laborers in the Belorussian SSR will ensure a one-percent reduction in the materials-intensiveness of national income, up to 70 percent of the increase in resources requirements will be met through savings, and profits over and above the plan will reach 150 million rubles. Such are the initial results of recent party and government resolutions aimed at developing the creative initiative of labor collectives and at intensifying national economic development on the basis of accelerating scientific-technical progress.

A leading role in resolving the tasks of saving resources in machine building in the five-year plan just ahead will belong to the use of metal-conserving plastic forming, whose advantages are well-known. Enterprises must resolutely and consistently reject traditional processes involving cutting and shift to low-waste forming processes. To do this, we need to restructure production, re-examine the parts products mix, increase series production,
technical and organizational steps.

The pages of this journal illuminate modern achievements in pressure-working metals and ways of improving it. Under actual production conditions, the engineering community is achieving considerable savings through efficient layout, by optimizing blanks and using parts mills, and so on. The collective at the AvtoVAZ enterprise has been an initiator in new socialist competition by manufacturing forgings with a materials use factor improvement of from 0.77 to 0.84. Planned work by the engineering collective at the "Avtonormal" plant (in Belebey) aimed at improving the cold die forging process has permitted expansion of the products mix by 1,000 items while raising the KIM [materials use factor] to 0.85.

Enterprise workers now face tasks aimed at retooling domestic machine building. A role of considerable importance in resolving these tasks belongs to scientists at the branch institutes and VUZ's. They are faced with creating the theoretical principles and practical construction of flexible manufacturing systems for sheet and die forging. This will also necessitate the development of new technological processes, re-adjustable systems including equipment and tools, transport and modern warehousing for materials, items and press tools.

These tasks need to be resolved with consideration of the progressive trends characteristic of the current state of pressure-working processes. Examples would be: die and sheet forging processes and a combination of plastic shaping and forging, the use of continuous casting for blanks, manufacturing complex shaped parts from thick sheet instead of casting and welding, and many others.

The development of modern methods of plastic-working composite and powder materials for use as possible equivalent replacements for traditional metals and allows is an important problem.

We must not be content with the certain successes which have been achieved in the use of pulse techniques, explosions, and gas- and hydrostatic devices. The use of deformation with extremal parameters still conceals many unused reserves, and ways must be found to begin using them in the domestic economy. The same would also apply to using deformation under isothermic and superplastic conditions. Here, we will require the joint efforts of physicists, metallurgists and branch specialists.

The scientifically substantiated use of recycled materials and scrap is an enormous raw material reserve for machine building. For example, recovered aluminum alloys obtained from scrap and chips can, when suitably processed, be equal to ordinary alloys in terms of their mechanical properties and can be easily forged and stamped to manufacture domestic machinery parts. In the Soviet Union, such alloys could account for more than a quarter of all aluminum and aluminum alloy production. It should be recalled in this regard that the energy intensiveness of producing recycled aluminum alloys is 10-15 times less that than of primary metal production.

Based on experience at the ZIL, AvtoVAZ and many other enterprises, given proper organization, the use of cutouts or notching, flash, strip and other scrap can provide substantial savings of steel and alloys.

Production workers and scientists must jointly seek and find a solution to the important task of ensuring cardinal changes in metal consumption by machine building enterprises and produce fruitful prescriptions and methods for the economical expenditure of materials when producing machinery for the national economy.

Metalworking production will be retooled by delivering new machine tools, forge-press machinery and other technological equipment designed for low-waste technological processes. Machine tool manufacturers have been set the goal of significantly enriching the country's metalworking with modern machinery, automatic complexes and lines meeting the demands of modern industrial production. This also offers another opportunity to conserve materials when producing this equipment.

The present level of machine theory and the use of numerical end-element calculations which take dynamics and other factors into account enable us to abandon the incorporation of large strength safety margins in machine parts and to ensure appropriate optimization of their shapes and sizes. Mathematical modelling of processes and stress-deformation permit reliable evaluation of the actual operating conditions for machinery as a whole. The experience of a number of scientific research institutes and plants, and in particular, that of the Voronezh Heavy Mechanical Press PO, demonstrates that good organization of the reliability service, integrally linked to a study of operating experience and to competent, theoretically substantiated machinery design, provides an opportunity to develop improved machinery and automatic lines with superior parameters, including ones superior in metals intensiveness to analogs produced by famous foreign companies.

Another reserve for saving metal is the use of higher-quality steels, such as EShL blanks for domestic parts.

This journal will constantly illuminate the best achievements of leading enterprises in saving material resources and introducing improved metal-conserving machining processes. We hope the journal's active authors and its readers will take a most active part in this important cause.

11052
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EXHIBITION OF PRODUCTS EMBODYING NEW TECHNOLOGY

Moscow EKONOMICHESKAYA GAZETA in Russian No 10, Mar 86 p 24

[Article by A. Kondrashov: "Science - Technology - Production 86" Slant lines denote material in boldface.]

[Text] /On the occasion of the 27th Congress of the CPSU 50 exhibits, 13 displays and 156 special exhibitions have been prepared at the VDNKh [Exhibition of USSR National Economic Achievements]. The best and most advanced achievements in various sectors of the national economy, science and technology are being displayed these days in the various pavilions and in the outdoor stands.

We report on the largest exhibition of the year, which opened in Pavilion No. 3 for intersectorial exhibitions:/

Viktor Nikitin, an engineer of the Poisk Center for Scientific and Technical Information in Moscow, lucked out, we have to admit. As one of the engineers developing the Rotor-1 industrial robot for transporting and storing blanks and finished parts he tested it only yesterday at the flexible production module set up by the specialists of the Krasnyy Proletariy plant and now is preparing to show it at the largest exhibition of the year.

At a small demonstration stand set up in Pavilion No. 3 for intersectorial exhibitions the robot, which looks like a bumper car, hustled back and forth tirelessly among the machine tools that are set up here. Approaching a rack, it picked up the next "batch" of blanks, transported them to another robot arm set up next to the unit and hurried to carry out the next operation: to remove and carry the finished part produced on the semi-automatic lathe away to its place.

"Rotor-1," V. Nikitin said jokingly, "is our champion weightlifter." It is capable of transporting blanks weighing up to 200 kilograms. Models based on it with a lifting capacity 1.5 to 2 times greater have already been created. The main task of the robot is not to permit a minute of idle time. When it receives a command from the machine tool positioner it immediately rushes to carry out the order and load the unit with work.

In Pavilion No. 3 for intersectorial exhibitions, where the very large exhibition "Science - Technology - Production 86" just opened, there are many examples of one-of-a-kind equipment that ensure a signifi-

cant rise in the productivity of labor and quality of production. In its 19 sections 2,000 items and technologies from all the union republics along the main priority lines are displayed.

The following figures are also interesting. /The products of 80 ministries and agencies, the USSR Academy of Sciences and more than 800 scientific research institutes, design bureaus, scientific-production associations, enterprises and construction sites are on display./ Simply listing them indicates the attention devoted to the achievements of scientific and technical progress in our country.

For the first time a prototype of tomorrow's automated production is being presented. It can be seen from the example of a fragment of an enterprise with the automation of the whole cycle of production, beginning with the stage of designing, engineering and tooling-up for production and ending with the manufacture, quality control, transport and storage of the products. Of course unmanned technology presumes the full use of the most modern equipment, computerization and the introduction of automatic material handling equipment.

The organizers of the exhibition therefore had good reason to make the section "Automation of Production, Progressive Technological Processes and Materials in Machine Building" one of the leading ones.

Visitors will see a programmed controller guiding the Tsiklon 36 industrial robots of the Tiraspol casting machines plant, a numerically controlled universal tool milling machine and the robotized technological systems for assembling high-precision parts.

/Displays of new materials and also the equipment with which they are manufactured attracted the particular attention of specialists./ One display shows the Pusk 83 unit for ion plasma sputtering and a laser unit for the strengthening of splined parts. The proposed progressive technology for vacuum forming of thin films makes it possible to manufacture castings of complex shapes with a minimum machining allowance, to reduce the labor intensity by 35 percent and to save up to 60 percent on molding materials.

By using modern progressive composites in equipment scientists have been able to reduce the weight of machines significantly. The concrete results of their labor are on display: in just one airplane more than 2,000 parts made of plastics are used now. This reduced the weight of the aircraft by 1,800 kilograms and produces a saving of 15 tons of metal and 370 tons of fuel annually.

At a monitor screen we found the head of the applications laboratory of the Severodonets Scientific Research Institute for Control Computers, V. Shamardin. He is demonstrating the PS-3000 computer system, which is intended for high-speed data processing in research on the natural resources of the Earth, space research and oceanographic research.

"This system was developed by the Institute on Problems of Management and the

Impuls Scientific Production Association in Severodonets, which includes our institute too," V. Shamardin told us. "At present two new modifications of this machine, which by the way is the first of its kind, are being built."

The "Computer Technology and Communications" section, where the PS-3000 complex is being displayed, is one of the most impressive as far as the articles being displayed are concerned. The SM 1210 computer system, which is manufactured by the Orel Control Computer Plant imeni K.N. Rudnev association, demonstrates for the visitors an arbitrary program for controlling a complex technological process and games of logic. Automation equipment is represented by operating automatic capacity regulators and systems for the automation of design work. It is interesting that a special booth with computer games and videos of popular-scientific programs was set up for school children.

/A special feature of the "NTP-86" exhibition was the comprehensive discussion on measures to step up economic progress now being conducted by the enterprises of Moscow and Leningrad. /There are 600 items on display. They are found in all sections of the exhibition and show clearly the practical efforts of the Muscovites in the field of science, production, transportation, construction and daily life. The Leningraders brought to the exhibition the well-known exhibit "Intensification-90" in which the realization of an initiative approved by the CPSU Central Committee for the development of a territorial and sectorial "intensification" of the economy based on accelerating the introduction of the achievements of scientific and technical progress. A uniform system for training specialists for all sectors of the national economy - from the school to the institute for advanced training - deserves attention. One of the promising directions here is the use of flexible automated teaching systems (GAOS).

On finishing a tour of a section one's attention is drawn to the sign: "Additional information can be obtained in other pavilions of the VDNKh." The abundance of high-quality items on display at the NTP-86 exhibition makes it possible to locate them in the various pavilions and open-air stands devoted to a particular sector.

For example, the thematic exhibition "Scientific and Technical Progress in Shipbuilding" is in operation in the "Shipbuilding" pavilion. It is based on achievements in the fields of hull construction, building machinery for ships and maritime instrument making. The Biryuza-2 laser cutting machine, the Granat gas-cutting machine and a numerically controlled unit for cutting materials with a laser beam are just a few examples of the penetration of scientific and technical progress into the creation of modern high-speed ships.

Most of the equipment on display is manufactured not only as individual prototypes but also in series. It has earned a good reputation among the users too, aided in eliminating manual labor and increased the power available per worker.

The many sections of the NTP-86 exhibition reveal the experience of leading

enterprises in working under the conditions of the economic experiment and the achievements in the fields of aviation, maritime and river transport, the industrialization of construction and the chemicalization of the national economy.

The first responses by the visitors, tens of thousands of whom have already gone through the exhibit, indicate that interest is high and it will be embodied in the practical realization and industrial assimilation of many items of new technology, machines and equipment that were exhibited.

12893

CSO: 1861/232

NEWLY RE-EQUIPPED MACHINE BUILDING PLANT STILL NOT MEETING DELIVERY SCHEDULE

Baku BAKINSKIY RABOCHIY in Russian 7 Jan 86 p 3

[Article by Ch. Sadykhov and Deputy Chief of Production, Soyuzneftemash VPO, Z. Kuperman: "Sub-contractors not the only ones at fault."]

[Text] The issue at hand was already addressed by this newspaper nearly one year ago. An article published on January 24 dealt in detail with what was preventing the Kishlinsk Machine Building Plant from fulfilling their contractual obligations. The newspaper looked into this issue in response to an alarming letter from the Noyabrskneftegaz Production Association which was received by the editorial office. The letter stated that several VPO Soyuzneftemash Plants were interrupting the delivery of equipment to oil-industry workers in Tyumen.

After the article appeared, the editorial staff received a reply from the Soyuzneftemash Association. Admitting that the criticism was on target, the association pledged to do everything in its power to prevent future deliveries from being interrupted. This related to all plants of the association. Only one year later, the editorial staff again received a letter from the Noyabrskneftegaz Association in Siberia. The letter stated that five VPO Soyuzneftemash Plants interrupted deliveries in the third quarter of 1985, and some even did so in the second quarter.

This time, Noyabrskneftegaz lodged its biggest complaint against another enterprise, namely the Bakinsk Machine-Building Plant imeni Lieutenant Shmidt. According to the letter, the workers at this machine-building plant still owed a considerable amount of equipment to the oil-industry workers. Four items were on the list - a Christmas tree, two kinds of casing heads and one kind of valve. Some of the equipment was supposed to have been shipped to the workers in Tyumen back in the second quarter already.

Such a state of affairs was sure to raise a few eyebrows. The enterprises of the Soyuzneftemash Association have been operating under the conditions of an economic experiment since January 1985, in which successfully meeting the delivery schedule outlined by the plan is the main indicator of their economic efficiency. There was another reason why no interruptions in delivery were expected as well. Much has been done to renovate and re-equip production in recent years. New shops equipped with state-of-the-art tools have been made operational, each one of which may be viewed as being an

entire self-contained plant. Christmas tree and casing head shops are among them.

It is said that those who did not achieve a set objective are not the ones that should be reproached, but those who did not use any and all means at their disposal to do so. It is precisely on the other group that attention should be focused.

The team working in the Machine-Building Plant imeni Lieutenant Shmidt worked somewhat better in the last year of the five-year plan than it had before. The new plant administrators managed to accomplish a great deal. Created in vacated production areas in particular were an experimental machinery and repair shop, which will serve as the basis for introducing new technology, and a machinery and repair section to service steel casting production. Brigades have recently been organized in a more thoughtful manner and with greater efficiency. An industrial brigade headed by the two brigade leaders Nadi Binnatov and Vladimir Ganziyeli has been established in the Christmas tree shop. Working conditions which stimulate highly productive work without the production of any defective products have been developed. There are 140 workers in the brigade.

For a long time, the plant could not put NC machine tools and robotized complexes in good working order. The plant administration managed to select skilled specialists and establish an industrial team headed by R. Danilyan for repairing and operating this technology. The first successes are already evident - 10 new machine tools and three robotized complexes have already been put into operation.

A lot of work has been done. Even so, some think that the administration neglected one equally important aspect--the necessity to fulfill the plan in total conformity with the products list stipulated.

When we got around to talking about what was actually the reason behind the incomplete and late deliveries, plant employees explained this by the fact that they were also being put in a spot by sub-contractors.

"Our suppliers in the cooperative system", explains O. Ragimov, deputy plant manager for production matters "are the plant imeni S.M. Kirov, the plant imeni Montin and the Bakinsk Steel Casting Plant. They supply us at irregular intervals with complete units and components as well as with castings. And this is the main reason for the disruptions in deliveries which occur at our end..."

Is this really true? It so happens that sub-contractors did not disrupt deliveries to the plant for eleven months last year. It is true that the regularity with which deliveries are made leaves a lot to be desired. As a rule, no more than 11 percent of the complete production is delivered within the first 10 days of the month, while from 64 to 66 percent is delivered in the final 10 days. The regular tempo of work at the Plant imeni Lieutenant Shmidt is the same, as it puts out 17 percent in the first 10 days and 59 percent in the last 10 days. This phenomenon is in itself

abnormal, and the tempo of production should be better organized. This is the best "medicine" against too much stress and overtime work.

Some believe that the main reason behind all of this has absolutely nothing to do with the subcontractors letting the plant down, but with problems in organizing production at the plant itself. Statistics from the first 11 months of 1985 show that the plant failed to fulfill the plan for 11 out of the 16 items on thepproducts list.

A topic of extreme urgency involves the production of spare parts for oil-field equipment. Workers in the oil industry can prolong the lifetime of operating equipment when these items are in stock, since they can replace the parts which wear out the fastest. The plan for their manufacture has been stalled by the plant. This is a very touchy subject for the Bakinsk "Neftemashremont" office, which handles the distribution and shipment of these spare parts to the users.

On the other hand, there are some items on the products list for which the plant over-fulfilled the plan considerably. Many products were realized at a delivery rate which outstripped that outlined in the plan.

What does this all actually mean? The steps taken on the part of the administration, party organization and People's Control in the fight to achieve strict compliance with contractual obligations continue to be largely ineffective. The timetables for fulfilling the plan as per the products list with regard to delivery organization are frequently not met because of the production department at the plant, which is headed by M. Mamedov. We saw the timetables at other plants which were checked daily. Any time a delay is noticed with regard to a certain item, corrective measures are taken immediately. Workers at the Plant imeni Shmidt should aspire to an accurate production control service such as this.

The plant director, I. Guseynov, assured us that full delivery would be made of supplies to Western Siberia and areas to the north come rain or shine. The plant has quite a few resources. The number of cost accounting industrial teams which proved their worth will increase. The inventory of new and highly productive machine tools will also increase (some have already been received, but have not been set up or installed as of yet). Steps will be taken for ensuring that each shop and team strictly fulfills its tasks with regard to the products list. In combination with the quality of work accomplished, this will be most important when determining the economic incentives to be handed out.

One might thank that if all these steps are actually put into effect and compliance with them is strictly enforced - and the intensive plans of the 12th Five-Year Plan will hardly be fulfilled without this - workers at the Plant imeni Shmidt will manage to eliminate the delays and do their part in providing workers in the oil industry with the equipment they need.

9638/9835
CSO: 1861/195

UDC 621.825.52

PROGRAMMABLE POSITIONING JIG FOR RADIAL DRILLING MACHINES

Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 1, Jan 86
pp 28-29

[Article by S.I. Gontarevskiy, engineer]

[Text] A jig has been developed at Lvov Polytechnical Institute for program control of the machining of a set of holes on radial drilling machines. The use of this jig makes it possible to perform the preliminary machining of holes by drilling with minimal allowances for machining, with accuracy of the relative position of holes of less than 0.05 mm, and final machining with accuracy of the relative position of holes of greater than 0.05 mm.

The jig (cf. figure) consists of a cross-shaped table making it possible to move a part fastened to it along two coordinates in the horizontal plane, and an electronics unit which controls the operation of the table according to a program. On the body, 6, and carriage, 2, of the cross-shaped table is mounted a drive consisting of a d.c. motor, 7, and a speed reducer, 3, with an electromagnetic clutch. The speed reducer's output shaft is connected by the clutch to a feed screw, 1. The drive makes it possible to move the carriage in accordance with the program, which is entered into the unit's memory by means of a keyboard. The capacity of the unit's memory makes it possible to input more than 500 movements for each coordinate. For the purpose of speeding up input of the program it is necessary to recalculate the dimension chains, using the machined side surface as a basis, and then to input the program in absolute values of dimensions. As a result of the use of a buffer power supply, the machining program is saved when the unit is disconnected from the power line.

In the automatic mode the order of the transmission of program points in the working process can be the same as the order of the input of the coordinates of points, and in the semiautomatic mode it is determined by the operator. In the manual control mode the drive makes possible movements of the table's carriages, the magnitude and direction of which are monitored by means of a digital display.

A duodirectional photoelectric transducer, 4, is designed for displaying movements of the carriages. The translational displacement of the carriages by rack-and-pinion transmission 5 is converted into rotational motion of the

shaft of the photoelectric transducer, 4, and then into electrical pulses whose number is proportional to the angular displacement of the converter's shaft. The pulses arriving from the photoelectric transducer are summed by a counter and are displayed by the digital display. When the parameters indicated on the display agree with those specified by the machining program, the drive is switched off. The travel speed is reduced as the program point is reached for the purpose of ensuring the required positioning accuracy.

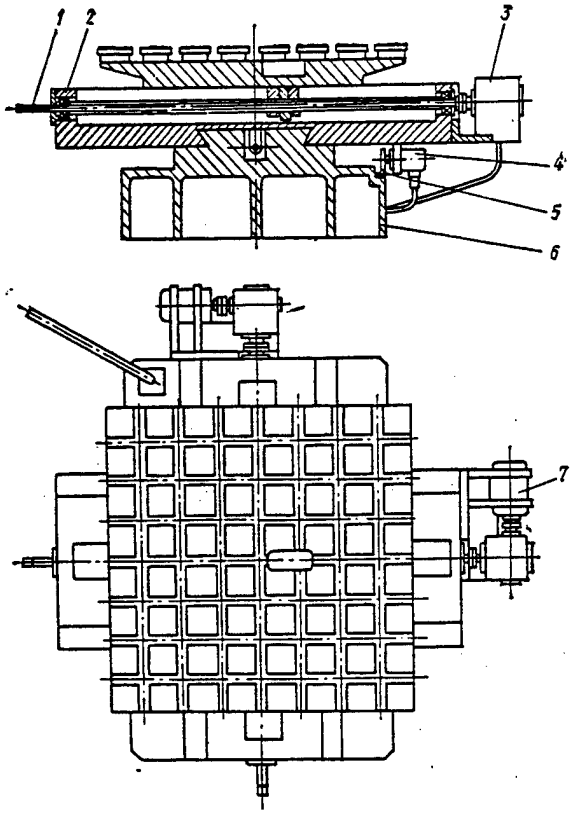


Figure 1. Jig for Program Control of Machining a Set of Holes on Radial Drilling Machines

When working on drilling machines furnished with this jig it is advisable to use turrets, which considerably shorten the time it takes for tool replacement.

The economic efficiency of using this jig is determined chiefly by the reduction in ancillary time and by improvement of machining precision and productivity.

8831
CSO: 1861/145

UDC 621.771.07:621.771.063:669.14.253

NEW PROCESS FOR MAKING WORKER ROLLS FOR MULTIROLL HELICAL ROLLING MILLS

Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No. 12, Dec 85 p 17

[Article by A. A. Kuz'minykh, V. A. Polozovskiy, I. I. Razbezhkin and I. N. Potapov]

[Text] The low durability of the worker rolls made of steel with increased chromium content (2 to 14%) used at the present time for cold rolling of high-precision kinescope tape on multiroll mills leads to the occurrence of up to 70% rejection of tape for the following flaws: "grid," wave, vertical stripes and warping.

In order to improve the endurance of the rolls and reduce the rejects it is expedient to use R6M5 tungsten molybdenum steel and a new process for making rolls on the three-roll helical rolling mills. A process has been developed for making worker rolls 45 mm in diameter and 800 mm long for the 20-roll 700 mill at the Magnitogorsk Integrated Iron and Steel Works imeni V.I. Lenin which includes helical rolling of a continuous billet 80 mm in diameter in two passes with maximum unit reduction to 30%, heat treatment for hardness HRC_e 63 to 65 and subsequent machining (grinding) to the finish size.

Helical rolling of the rolls offers the possibility of obtaining fine-grained structure and reduction of the carbide inhomogeneity to a minimum with respect to the entire transverse cross section of the roll, improvement of the strength of R6M5 steel by 25 to 30% and reduction of the rejection of tape for flaws by 50 to 60%. The labor intensiveness of manufacturing the rolls has been decreased by 2.5 to 3 times.

The worker rolls made by the given process have passed experimental industrial testing for the production of kinescope tape 565 by 1.5 mm on the 700 mill. The expected cost benefit is more than 90,000 rubles a year.

10845
CSO: 1861/128

UDC 621.983:621.229.6

AUTOMATED SYSTEM BASED ON 63 kN MODEL AKKD 2118A.03 SINGLE-CRANK PRESS

Moscow KUZHECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 12, Dec 85 pp 18-19

[Article by Ye. F. Kuchmeyev, V. V. Goshtalek and A. D. Yerokhin]

[Text] The Taganrog PKTIkuzrobot Institute has created an automated system based on the 63 kN model KD2118A open single-crank sheet-stamping press, which includes a light model KMO 08Ts4211 pneumatic manipulator with load capacity of 0.08 kg (Figure 1) built in the same class as the model KMO 63Ts4212 manipulator. Its distinguishing features are smaller size, lighter weight and lifting capacity and higher output capacity.

The majority of the cold stamping operations performed on open crank presses do not require a broad array of movements or high precision, and for automation of the stamping process it is possible to use comparatively simply designed, high speed industrial robots. The automated model KMO 08Ts4211 manipulator corresponds to these requirements. Its kinematic diagram is presented in Figure 2.

Technical Specifications of Model KOM.08Ts4211 Manipulator

Lifting capacity, kN:	
Rated	0.08[1]
Maximum	0.25[2]
Number of arms	1
Positioning precision, mm	±0.1
Number of degrees of mobility	2
Maximum servicing radius, mm	200
Angle of rotation, degrees:	
Without lifting	180
With maximum lift	120
Amount of lift (lowering), mm	12
Number of positioning points	2
Speeds with maximum displacements:	
Rotation in horizontal plane, degrees/ sec	400
Lift (lowering), m/sec	0.16

Feed network current	dc
Voltage, volts	24
Air pressure, MPa	0.45
Overall dimensions in plan, mm	260X750
Height, mm	160
Weight, kg:	
Manipulator	7
Pneumatic control	10

[1]For gripping device weighing no more than 0.5 kg.

[2]For billets weighing over 0.08 kg, the speeds must be reduced by 30 to 50%.

Figure 1

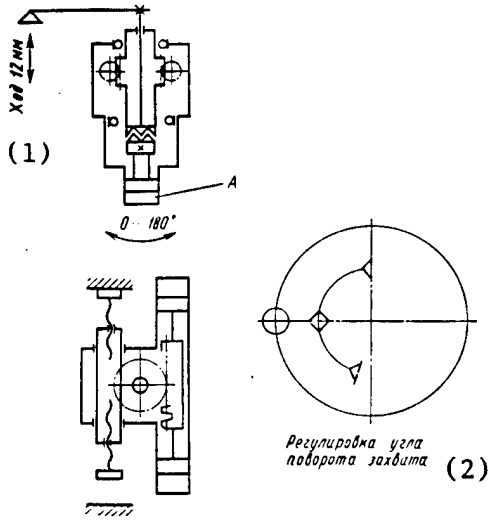


Figure 2

Key:
1. 12 mm stroke
2. adjustment of angle of rotation of the gripping device

A two-way pneumatic motor, the rectilinear movement of the pistons of which is converted to rotation of the arm in the horizontal plane and vertical movement of it at the extreme points of rotation, is used as the drive (Figure 3). A pinion 6, in the lower part of which end type cams are installed, is placed in ballbearings in the housing 5 of the drive. The pneumatic cylinders are connected to each other by a toothed rack 4 which drives a pinion in circular movement. A shaft 1, on the lower part of which a halfcoupling 8 is installed with end cams, passes through the pinion. The arm is attached from the top with gripping device 10 and stop 9. In the lower part of the shaft there is a cavity which the piston located in the lower cover 7 enters. The air fed to the shaft cavity clamps the cams of the halfcoupling to the cams of the pinion. The total angle of rotation from the pneumatic motor is 180°. There is no lift with rotation of 180°. Lifting by 12 mm corresponds to pinion rotation of 30°. Therefore when lifting by 12 mm in the extreme positions, the maximum rotation is reduced to 120°. The angle of rotation is adjusted by stops 2 and 3.

The pneumatic system of the manipulator (Figure 4) provides for its operation in an established cycle.

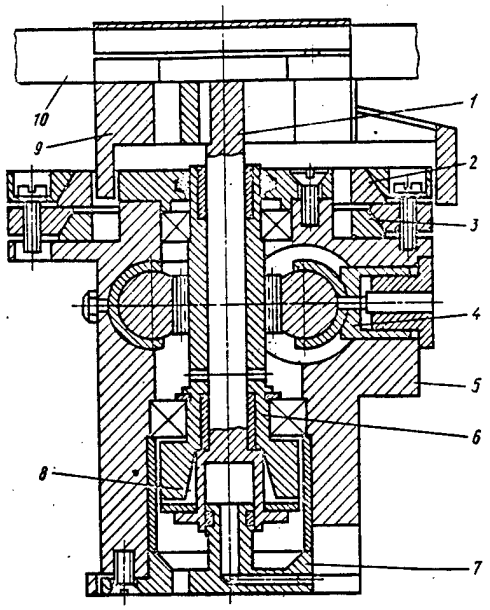


Figure 3

From the pneumatic system, the compressed air goes to a preparation unit where solid particles and water are removed from it, it is reduced to a pressure of 0.45 MPa, it is saturated with atomized oil and simultaneously fed to the pneumatic control valves P_1, P_4; P_5, P_6, P_7 of the manipulator.

Depending on the initial position of the pneumatic control valve P_1, the pneumatic motor D presses on the button to switch one of the control valves on (P_5 or P_6) at the end of rotation through a rack and flag. The air switches the P_4 air control valve through the air control valve that is on and, accordingly, the pneumatic control valve P_1 for movement in the opposite direction. At the end of rotation, the pneumatic motor D switches on the other pneumatic control valve by pushing on a button. These cycles repeat.

A drive for the gripping device required in accordance with the technological process is connected to one of the control lines of the pneumatic control valve P_1, which insures interpolation of the direction of rotation of the pneumatic motor and, consequently, the arms of the manipulator and response of the gripping device (pick up or set down). The lead of the response of the gripping device from the beginning of rotation of the arm is provided for by adjustment of the chokes DR_3 and DR_4.

By using a manual switch on the pneumatic control valve P_3, the pneumatic system of the manipulator is set to the "adjust" or "automatic" position. The pneumatic system is switched to operation with a claw (cylinder Ts), electromagnetic (pneumoelectric converter PEP) or vacuum (ejector E) gripping devices on the control panel of the manipulator by connecting the corresponding nipples.

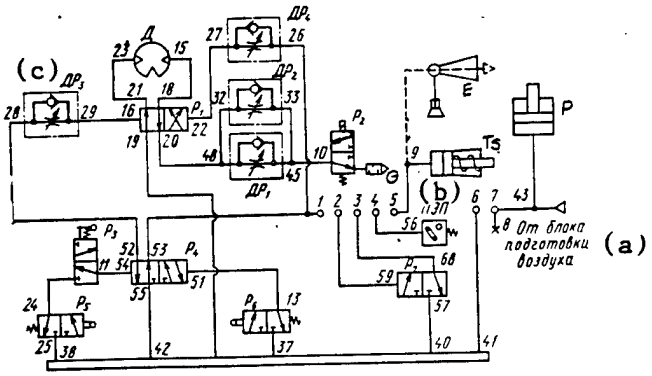


Figure 4

Key:
- a. From the air preparation unit
- b. PEP - pneumoelectric converter
- c. DR_3 choke

The pneumatic control valve P_7 feeds air to the ejector E.

The speed of the electric motor is varied by adjusting the chokes DR_1 and DR_2, the noise level from the air exhaust of which is reduced by a muffler.

A working pressure of 0.5 MPa and minimum pressure of 0.35 MPa are established in the air preparation unit. The manipulator is connected to the complex through the electropneumatic valve P_2.

The model KMO 08Ts4211 manipulator can be used in the systems with different models of single-crank, single-action, open presses to 1000 kN, and it can be used for stamping parts weighing up to 0.25 kg from piece billets.

The automated system model AKKD2118A.03 developed by the PKTIkuzrobot was built on the basis of the 63 kN model AKKD2118A press.

Technical Specifications of the Model AKKD2118A.03 System

Rated force of the press, kN	63
Weight of stamped work pieces, kg (no more than)	0.1
Dimensions of sheet billets, mm:	
With thickness of sheet rolled product 0.5 to 2.5 mm	40X90
Output capacity of complex, pieces/min	50
The same, pieces/shift	19200
Positioning error, mm	±0.1
One-time loading of hopper, kg	40
Compressed air consumption, liters/cycle	0.8
Dimensions in plan, mm	1400X1800
Height above sea level, mm	2000
Weight, kg	1100
Type of control system	Cyclic
Operating modes of system	Adjustment, cyclic, automatic

For a billet weighing more than 0.08 kg, the output capacity is decreased by 30%.

The system equipment is installed on a podium. This makes it possible to change the layout of the section if necessary easily without building expensive foundations. The press is installed in the center of the podium. In front of the press, a base with the manipulator and the button control system for the press are fastened to a bedplate at the button control location. The fastening of the press base permits it to be adjusted as a function of the height of the die surface. A receiving table with a sensor for checking the billet for the initial position is fastened to the same base on the left. A vibrating bin with a drive is installed in front of the press on the left. The air preparation unit is located at the bottom between the uprights of the press on brackets. A pneumatic relief valve is fastened to the die backing plate of the press. A guide trough is fastened at the rear on the bedplate, and a container for the parts is placed under it.

The system is controlled from a panel located on the podium. All of the adjustment and control elements are coupled out to this panel. The system operates as follows. The billets are fed from the vibrating bin to the receiving table. When the slide block of the press reaches top dead center

and a signal is received from the sensor of the presence of a billet in the initial position (on the receiving table), the electropneumatic valve is switched on, and the operating cycle of the manipulator is completed. After placement, the manipulator arm returns to the initial position, and the working stroke of the press is switched on. On completion of the working stroke, on the way to returning to top dead center the slide block switches on the pneumatic relief valve, which clears the stamped part to the trough from which it rolls into the container. After the slide block returns to top dead center, the cycle repeats. The design provides for blocking that prevents the system from being switched on or operated with the front guard of the press raised, if the billet is not present or is not correctly positioned on the receiving table. On duplication of the working stroke of the slide block, the placement of the billet in the die and removal of the part to the container are checked. Provision is made for shutting down the system when the next operating stroke does not take place for a period of time equal to two or three cycles as a result of absence of a billet, lack of response of the blocking, failure, and so on.

The systems are manufactured in series at the Kursk Plant of the Kursk Production Association.

The cost benefit from introducing the automated cold-stamping system is more than 9,500 rubles a year.

10845
CSO: 1861/128

UDC 621.774.8-4

NEW TECHNOLOGICAL PROCESS AND EQUIPMENT FOR TAPE FINNING OF TUBES

Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 12, Dec 85 p 20

[Article by V. P. Mulin and N. I. Chernikin]

[Text] Finned tubes are used as heat-exchange elements in many branches of industry, petrochemical, gas, power engineering, in cold machine building and other branches utilizing various types of heat exchange equipment.

In Soviet industry, the production of finned tubes is based on helical rolling on three-roll mills designed by the VNIImetmash Institute. Bimetal tubing--steel tubing with AD1M aluminum tubing pressed on it--is used as the initial billet. The output capacity of such machines when producing finned tubes (supporting pipe diameter 25 mm, fin diameter 57 mm, fin pitch 2.5 mm) is 6 running meters per minute. However, as the feasibility study demonstrates, the replacement of the indicated process of finning tubing from bimetal pipes by tape finning of the tube results in a decrease in aluminum consumption per running meter from 1.5335 to 0.868 kg. The electric power consumption is reduced by 2.3 times, and the labor intensiveness is almost cut in half.

Considering these high technical-economic indices, the ENIKmash Institute has developed a new process for tape finning of tubing and has built some highly efficient equipment. A new method of bending the tape on edge has been developed for implementing the tube finning process. This method makes it possible to obtain a continuous spiral with smooth edge.

Studies have established that the developed method permits bending of tape made of various materials on edge: aluminum, copper, brass, steel with geometric proportion of $r_{ins}/B<1$, $B/h\approx50$, where r_{ins} is the inside radius; B is the width and h is the thickness of the tape.

Figure 1 [not included in the translation] shows samples made of different materials and with different geometric proportions.

From this figure it is possible to conclude that the range of machined materials and the dimensions of the obtained spirals are significant, which characterizes the high technological possibilities of the new method of bending tape on edge.

The tool for bending tape on edge consists of a forming flange rigidly attached to a housing and a rotating tool which on interaction forms a gap between its working surfaces sufficient for permitting the bend.

The forming flange can have one, two or more guide channels which permits simultaneous bending of several tapes.

Research has established the high precision of the geometric dimensions of the obtained spirals independently of the speed of rotation of the tool at least in the range of practically acceptable speeds to 1600 rpm.

Based on the new, efficient method of bending of tape on edge, the ENIKmash Institute has developed a technological process for tape finning of tubes, the diagram of which is presented in Figure 2.

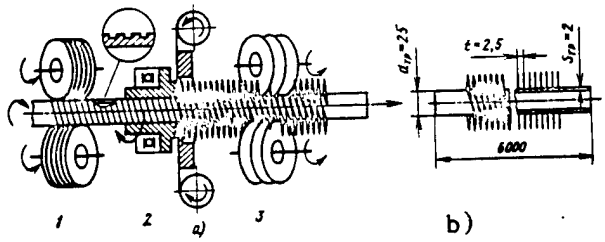


Figure 2. Diagram (a) of the technological process for tape finning of tubes and a drawing (b) of a finned tube

The technological process is executed as follows: a spiral groove (1) is rolled on the tube (see Figure 2)--single or multiple thread--depending on the number of simultaneously rolled spirals. The tube is turned and displaced in the longitudinal direction by means of the knurling rolls. Then the tube with the spiral grooves goes to the coiling tool zone where the tape is coiled into a spiral directly in the spiral grooves (Figure 2, 2). The tube with the spiral winding goes to the flaring zone, where the spiral is secured in the spiral grooves by means of flaring rolls (see Figure 2, 3) in the form of flat discs, the thickness of which does not exceed the spacing between adjacent ribs of the spiral.

For the process to take place stably, the initial tubing must correspond with respect to outside diameter to All-Union State Standard 9567-75 or be sized to the required dimensions.

The developed process of tape finning of tubes is taken as the base for the creation of specialized equipment (Figure 3) which consists of the following main assemblies and mechanisms:

The rack for charging the initial tubes; sizing, knurling, coiling, uncoiling, and flaring devices; the cooling and lubricating fluid system, the receiving rack, the holder for the finned tubes.

The line operates in the automatic mode with output capacity of 6 to 7 running meters of finned tubes per minute (for initial tubes 25 mm in diameter, fin diameter 57 mm, fin pitch 2.5 mm, tube length to 6 m).

A line for tape finning of tubes has been introduced at the Tallin Machine Building Plant imeni Lauristin.

Conclusion. A new technological process for tape finning of tubes based on bending tape on edge provides for significant amounts of finning metal to be saved. The equipment built to implement the process is distinguished by high efficiency and economical consumption of electric power.

The process and the equipment can be recommended to enterprises manufacturing various types of heat exchange equipment--refrigeration plants, air cooling units, air heaters, thermoelectric heating elements, and so on.

Figures not included in the text.

Figure 1. Samples made by bending tape on edge:
a--steel; b--aluminum

Figure 3. Line for tape finning of tubes.

10845
CSO: 1861/128

UDC 621.791.039(088.8)

A PLASMATRON MANIPULATOR FOR A VERTICAL BORING AND TURNING MACHINE

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 12, Dec 85, p 6

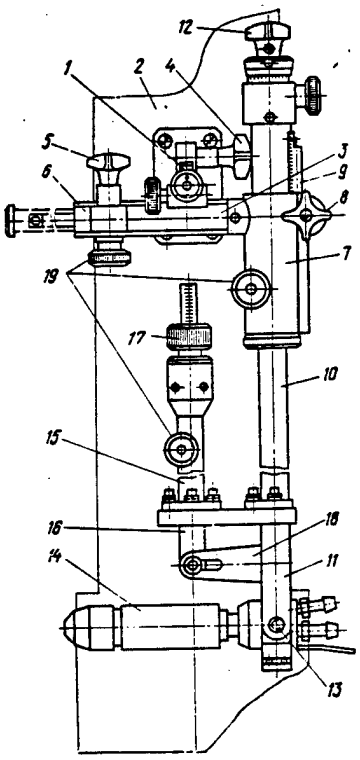
[Article by Engineer V. P. Vlasov]

[Text] The All-Union Technology Project Institute for power engineering has developed a plasmatron manipulator, designed to regulate the position of a plasmatron relative to the workpiece during plasma machining on vertical boring and turning machines. The manipulator (figure), which may be used to machine difficult materials with plasma heating, includes a rack 1, secured to the slide 2 of the machine. A movable sleeve 3 is mounted on the rack 1, with handles 4 and 5 and gears. In the sleeve, perpendicular to rack 1, is mounted a rack 6, at the end of which is fastened a sleeve 7 with handle 8. In the sleeve 7 is a hollow rack 9 with shaft 10 inside. At the lower end of the latter is secured a clamp 11, at the upper end a handle 12. In the clamp, a collar with plasmatron 14 is mounted on pivots 13 and is able to turn. Connected to the clamp is a hollow stand 15 with screw 16 inside and a nut 17. The lower end of the screw is linked across a lever 18 to the collar of the plasmatron. All the moving parts (racks, shaft and screw) can be locked by screws 19. There are lengthwise slots in the sleeves, making contact with the lateral surfaces of the racks.

To aim the plasmatron at the surface for heating, horizontal motions along the axis of the slide and perpendicular to it are performed by turning the handles 4 and 5, whereupon the gears move the racks 1 and 6. Vertical movement of the plasmatron is achieved by turning the handle 8, whereupon the gear moves the rack 9. The turning of the sleeves on the racks and of the racks in the sleeves is limited.

By turning the handle 12, the shaft 10 with the plasmatron clamp is rotated, i.e., the plasmatron is turned in the horizontal plane. In the vertical plane, the plasmatron is rotated by turning the nut 17. This moves the screw 16 vertically and tilts the lever with the collar in which the plasmatron is fastened.

Linear scales are applied to the racks and screw to check the motions.



Plasmatron manipulator

The manipulator enables movement of the plasmatron by 150 mm along the X and Y axes, 60 mm along the Z axis, turning in the horizontal plane by 360° and in the vertical by 30°. The outside dimensions of the manipulator are 480 x 310 x 680 mm, the mass is 24.5 kg.

Adoption of the manipulator has improved the productivity of machining difficult materials, reduced the outlay of cutting tools and provided a savings of electricity. The annual cost benefit was 15,000 rubles.

12717
CSO: 1861/124

UDC Δ621.73.073:Δ62-229.7

A ROBOTIC TECHNOLOGY COMPLEX FOR THE FORMING OF TRANSFORMER PLATES

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 12, Dec 85, p 5

[Article by Engineers G. Ye. Vasilyev and S. N. Sanayev, Candidates of Technical Sciences A. A. Russkikh and B. V. Shcherbakov, and Engineer A. V. Kozhevnikov]

[Text] A rather broad assortment of industrial robots is being manufactured at present to replace manual labor in heavy, monotonous jobs.

However, the lack of an assortment of feeding and loading equipment is holding up their rapid adoption. As a rule, the loading and feeding devices developed for robotic technology complexes (RTC) are geared toward a particular type of billet or part with definite geometrical dimensions. Adjustment of the RTC to a different type of part with altered geometry involves replacement of the loading-feeding device, which consumes a lot of time during which the IR [industrial robot] and the equipment serviced by it stand idle. Especially great losses are observed in small-lot manufacture with a large assortment of products, e,g., the manufacture of blended-core transformers of medium and large power, where the number of rectangular plates used in a single magnetic circuit may reach 10.

The authors have created and tested in a transformer plate production line a RTC consisting of the manipulator MP-9S with control system, a loading-feeding device, a die-forming press and rollers.

The complex performs a punching operation, followed by rolling of the transformer plates with length from 20 to 350 mm and width from 15 to 100 mm.

The height of the stack of billets is 800 mm, the minimum billet thickness being 0.1 mm (the maximum thickness is bounded by the lifting capacity of the IR). The manipulator has an electromagnetic grip.

The layout of the robotic technology complex is shown in Fig. 1.

The robot and the loader-feeder have a common base, which enables the requisite precision of die forming. The loader-feeder is a well, lacking a front wall. The side walls 1 and the rear stop 2 are movable and travel on platforms 3 and 4 by screws 5 and 6 along guides 7 and 8. The feature 9 performs the function of

the front wall of the well for billets raised to the working level. The stack of billets is lifted by a bracket 10, connected to a lifting mechanism 11.

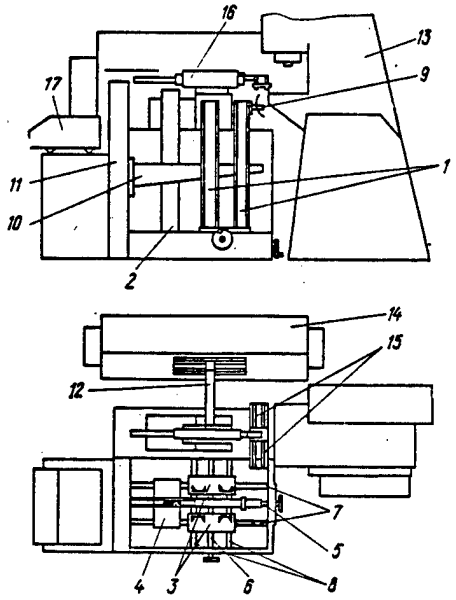


Fig. 1. Layout of the robot of the technology complex.

A bracket 12 is installed in the robot to function as a second arm, which grasps the finished plate from the press 13 and feeds it to the rollers 14. The electromagnetic grip is in the form of a base, which can travel on guides 15 relative to the robot arm 16 for grasping plates of either large or small size. The control console is 17.

The electromagnetic grip consists of a base 1 (Fig. 2), on which ten pairs of electromagnets are mounted.

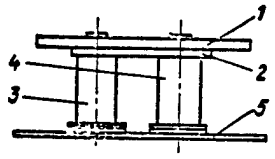


Fig. 2. The electromagnetic grip.

Each pair of electromagnets has a common collar 2, while the coil windings are connected in series. Thus, a magnetic flux closure is achieved across the first electromagnet 3, the collar, the second electromagnet 4 and the plate 5. The upper plate of the stack being grasped simultaneously functions as a screen for the remaining plates of the stack. In this way, only a single plate is grasped. However, in practice, instances of plate sticking occur (presence of oil, burr at the edge of the plate, etc.), and therefore during the grasping of the plate from the stack an alternating current is applied to the electromagnets of the grip, producing a vibration of the upper plate and its separation from the stack. After the lifting of the plate, all the electromagnets are supplied with direct current.

The proposed RTC can also be used for the die-forming of parts from nonferromagnetic material. In this case, it is only necessary to replace the electromagnetic grip with any other type, such as a vacuum grip.

The RTC lowers the net costs of production by 7400 rubles, and also frees up no less than four workers from the transformer plate manufacture process.

12717
CSO: 1861/124

UDC Δ65.012.122

EXPERIENCE IN THE DEVELOPMENT AND INTRODUCTION OF ROBOTIC TECHNOLOGY COMPLEXES (RTC) FOR COLD FORMING

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 12, Dec 85, pp 3-4

[Article by Candidate of Technical Sciences Ye. V. Novoselskiy and Engineers I. N. Svechkov and Yu. V. Khanin]

[Text] The Kiev Production Association Veda has developed and adopted an RTC (Fig. 1) for cold die forming in conditions of small-lot and multiple-item production.

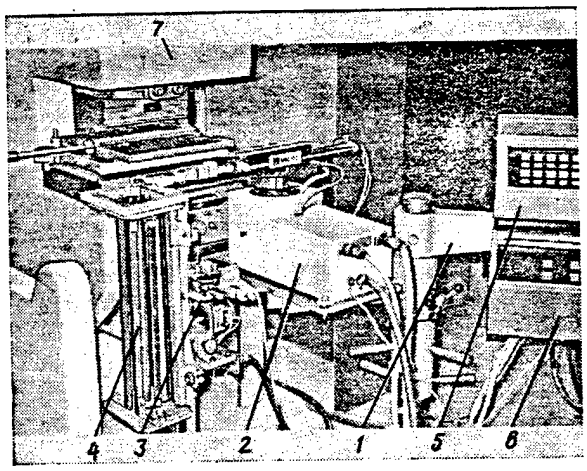


Fig. 1. The cold stamping RTC.

The RTC has been developed from an industrial robot (IR) model MP-9S and series KD presses of 245 and 392 kN. The RTK is composed of: pivoting support arms 1, on which are arranged the IR 2 and a billet dispenser 3 with interchangeable magazine 4; the ETsPU 6030 control system 5; a coordination unit 6 and the press 7.

The magazine, which can be adjusted to a broad range of sizes, avoids the need to manufacture and keep a large assortment of individual holders. The universal adjustable grip is designed so that its electromagnets or air suctions can be positioned at any spot of the billet for a reliable holding.

The operation of the first two RTC at the die forming section revealed a number of technical and organizational shortcomings, to eliminate which substantial corrections were made in both the design of the RTC and the organization of their introduction.

A reduced adjustment time of the RTC was achieved by introducing a mechanism for regulating the position of the magazine into the design of the flat billet dispenser. This dispenser (Fig. 2) consists of a lifting mechanism 1 with the RD-09 electric motor; a reducer and drum, joined by flexible cable to a carriage 2; a stand 3 with vertical guideways 4; an interchangeable magazine 5 with the billets 6; a sensor of the upper level of the stack of billets, mechanisms 8 for regulating the position of the magazine (movement of the magazine in the horizontal plane in two mutually perpendicular directions relative to the base 9 of the IR and turning about its vertical axis 10). The mechanism 8 (cf. Sections A-A and B-B) is in the form of a slider 11, furnished with two horizontal screws 12 and 13, crossing at a right angle. One of these (12) is connected to the base of the robot, the other (13) to a bearing 14, equipped with two guide pins 15 and two horizontally-situated segments 16 and 17 with slots 18. Segment 16 is toothed and can be turned by a gear 19, fastened to the bearing 14.

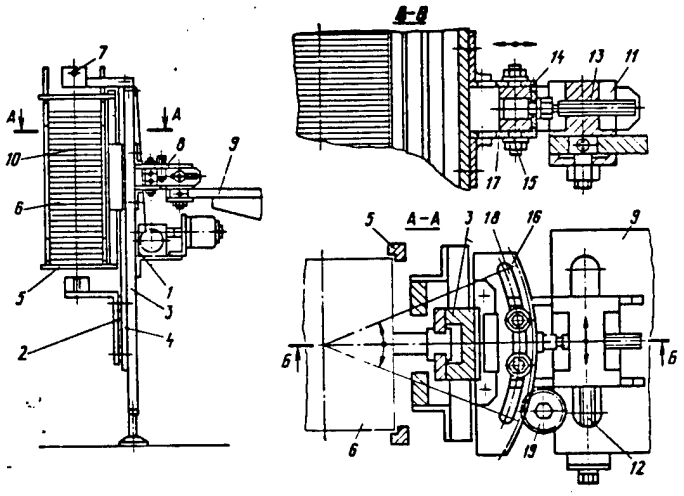


Fig. 2. Billet dispenser.

The device operates as follows. The magazine with the billets is placed on the stand; the lift mechanism raises the carriage, feeding the stack of billets to the grip position of the IR, determined by the setting of the level sensor. In

the set-up operation, the billet which is to be placed in the die of the press is carried by the IR into the zone above the carriage, after which the position of the magazine is regulated until the contours of the billets in the magazine and in the robot grip are aligned. The regulation is done by means of the mechanism 8 by turning the screws 12 and 13, as well as by the gear, followed by locking of the position of the slider, bearing and segments with respective fastening elements.

After the set-up, the billet dispenser is switched to automatic operation as part of the RTC.

The mechanism for regulating the position of the magazine enlarges the technological capabilities of the billet dispenser, enabling it to be used by RTC with different equipment, especially for small-lot and multiple-item production.

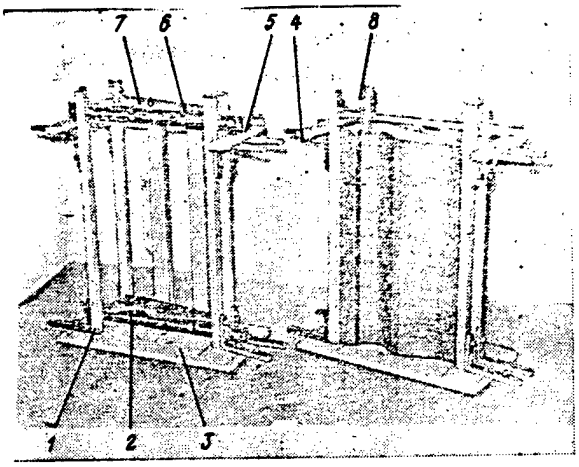


Fig. 3. Universal interchangeable magazine.

The design of the universal interchangeable magazine (Fig. 3) enables a simple and convenient storage and distribution of various standard-size billets. In practice, no more than one magazine is used, due to the possibility of adjusting the guideways 1 to the given size and shape of the billets by means of universal attachments 2 for adjusting the magazine to the template of the billet. The cross-shaped pusher and lower base 3 of the magazine provide a stable horizontal position of the billet, while the shape of the upper base 4 of the magazine allows fast filling of the magazine with billets.

The attachment for adjustment of the magazines has a lengthwise slot, along which there travel four locks 5 and 6, provided with pins. The pins of the two locks 5 are inserted into the base openings of the magazine. The two locks 6 are designed to secure the template 7 of the stock. The guideways of the holder are provided with slats 8 in the upper part, having mutually-converging wedge-shaped work surfaces, which increases the precision of orientation of the billets in the grip position.

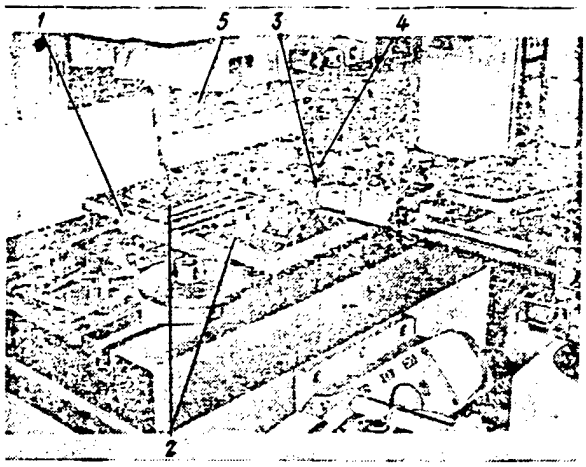


Fig. 4. Universal adjustable flexible die;
1 - base of die; 2 - adjustable slats;
3 - hand of IR; 4 - air blower; 5 - punch.

For the RTC a universal adjustable flexible die has been developed (Fig. 4), in which the part is inserted by the IR arm, and removed by compressed air. This has made possible the machining of more than 100 types of part by the RTC, without manufacturing special accessories. To remove the billets from each other at the IR grip position, a device has been developed for separating the billets by directed jets of compressed air from four nozzles, the position of which relative to the billets in the magazine can be regulated. Air is fed to the nozzles on instruction from the IR at the instant of gripping the billet, causing the second billet to be separated in event of sticking. To simplify the process of composing the RTC work program, eight standard programs have been developed, differing in the sequence of performance of instructions.

The robotic cold stamping segment consists of seven RTC on the basis of the IR model MP-9S, one RTC on the basis of the IR model PR4-2, and the RTC-206 robotic technology line, equipped with four IR model Gnom-3, two model KD-2126Ye presses, and a manipulator for transferring the parts from press to press.

The segment is operated by a team of one adjuster and two operators working at the RTC. Qualification characteristics and a wage schedule for workers at the segment have been developed. The segment is serviced by a maintenance and repair service for the NC and RTC equipment.

The experience in operation of the robotic stamping section has demonstrated that the use of the IR improves the labor productivity, increases the press workload up to a level of 0.75 and the shift factor up to 1.8, frees up six workers and produces an annual cost benefit of 25,800 rubles.

12717
CSO: 1861/124

UDC Δ62-77+629.119:Δ62-229.7(04)

A 'ROBOT SERVICE'

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 12, Dec 85, p 35

[Communication from Ye. B. Finkol of the city of Lvov under the rubric "Critique and Bibliography: Our Readers Write"]

[Text] The situation concerning the introduction of industrial robots (IR) at present is the following: the IR (at the disposition of the various ministries) arriving at the enterprises first reach the groups allocating robots to specific purposes. The end goal of the allocation group is to issue documents coordinating the IR and the automation target. Then, the start-up and adjustment organization of the sector gets into the act. The adjusters place the robots in service. But how many other times will the customers have to deal with the adjusters during the period of operation!

Only the enterprises of the radiotechnical industry are able to install, start up and operate the robots by themselves, as their engineering staff has all the requisite information for this.

The enterprises of the machine-building industry are in the worst shape, as previously an electronic engineer could only be found there in the ASUP [automated enterprise management system]. Yet the need for such engineers is growing with each year. Thus, the Lvov Bus Plant realized, although rather late, that the NC machines and the electrophysical machining equipment could not be operated without the attention of electricians.

The present system of robotization is ineffective--it does not allow the enterprises to bring the IR into the technological process in the shortest time.

Therefore, would it not be better to centralize the robotization service of each industrial region in a single organization?

The "robot service" (the most appropriate name for the future organization, in my opinion) is a kind of start-up and adjustment organization strictly specializing in robot engineering. The chain of command is centralized at an All-Union "Robot Service" Organization. Negotiations with the customers are possible on an individual contract basis. The duties of the "robot service" include not only placement in operation, but also subsequent adjustments and repairs. At the larger enterprises, the "robot service" should have expediting sectors.

In my view, the "robot service" should be directed by the chief robot installer, since all factories have a mechanical and power engineering service, and all that is needed is a competent supervision of the installation.

The presently-existing start-up and adjustment organizations of the sectors and the IR allocation groups at the factories are being replaced by a specialized centralized organization, responsible for everything.

12717
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UDC 658.52:519.2

PRODUCTIVITY ANALYSIS OF FLEXIBLE MANUFACTURING SYSTEMS BY METHODS BASED ON THEORY OF QUEUEING NETWORKS

Moscow MASHINOSTROYENIYE in Russian No 2, Mar-Apr 86
(manuscript received 24 Jun 85) pp 3-11

[Article by N.M. Ganin and V.Ya. Katkovnik, Leningrad]

[Abstract] The theory of queueing networks can be used for performance evaluation of flexible manufacturing systems (FMS), with an incoming blank treated as an object requiring service. Stochastic network models of FMS for multiple-product manufacture are considered first, such networks becoming deterministic only when the set of production system parameters is given. FMS productivity is accordingly evaluated in terms of (normalized) probabilities characterizing the output flux, the mean number of blanks in process, mean service time and equipment load factors. The line-balancing equation and condition for steady operation of the system yield an inequality which reveals a bottleneck. FMS with special accessories for loading-unloading and transport operations are describable by closed queueing networks and their productivity can be calculated (as a function of production system parameters) by solution of the corresponding system of linear algebraic equations. Unlike in open networks, there is no input or output flow. Instead, there is an equivalent circulation of pallets and their number, as well as the number of blanks or requisitions for service within the FMS network, remain constant. A performance evaluation by this method is demonstrated on a flexible manufacturing system consisting of n-1 sequential processing stations and palletization in the n-th station, the network model being a closed single-loop with respect to the pallets. The throughput of the model, and effect of the number of pallets and location of palletization station is briefly discussed. Figures 5; references 9: 8 Russian, 1 Western (in Russian translation).

2415/9835
CSO: 1861/341

UDC 621.80:007.52

CHARACTERISTICS OF REGULAR ROBOTIC STRUCTURES WITH CYCLIC CONTROL

Moscow MASHINOVEDENIYE in Russian No 1, Jan 86
(manuscript received 12 Oct 84, after completion 4 Apr 85) pp 9-18

[Article by L.I. Tyves and A.N. Sonin, Moscow]

[Abstract] Regular robotic structures, consisting of identical periodically repetitive kinematic elements and modules, are analyzed and algorithms of their discrete action are constructed on the basis of their properties. Boundaries of the work envelope are determined and cyclic control is designed for a most simple plane kinematic model consisting of N equally long rigid links coupled in series through class-5 rotational pairs with parallel axes. Each link has its own drive which rotates it relative to the preceding link; for simplicity, all links are assumed to rotate through the same angle at the same angular velocity. Analysis and synthesis are facilitated by use of an N-digit binary code, with "0" corresponding to the initial position of a link and "1" corresponding to its final position at angle ϕ relative to the preceding link. Both the forward problem of positioning and the inverse problem of configuring or coding are solved for the center point of the grip. Solution of the latter problem is particularly difficult, inasmuch as not all points within the work envelope are accessible to a discrete-action stepping manipulator. Therefore, the configuration or code is sought which will correspond to the minimum distance from the center of a grip to a given point on the plane of action. The important special case is studied where the center of the manipulator grip passes through points which form a regular grid. This is possible when the link rotation angle ϕ is 60° or 90°. Rules governing possible and impossible steps of a grip are established on the basis of the solution to the forward problem of positioning in terms of coordinates of the corner points on the broken-line boundary of the work envelope. For illustration, a set of six rules is established for a manipulator with a 90° link rotation angle. Figures 6; references 5 (Russian).

2415/9835
CSO: 1861/213

UDC 621.83

STRUCTURAL SYNTHESIS OF AUTOMATIC TECHNOLOGICAL MACHINERY FOR PROCESSING OF HEAVILY FILLED THERMOSETTING PLASTICS

Moscow MASHINOVEDENIYE in Russian No 1, Jan 86
(manuscript received 29 Apr 85, after completion 5 Aug 85) pp 3-8

[Article by A.D. Sokolov, Moscow]

[Abstract] The optimum design and layout variant of automatic manufacturing equipment for processing composite plastic materials with a volume fraction of the filler larger than that of the thermosetting binder is selected on the basis of structural synthesis following a material and process analysis. The principal process is forming the material into a product typically weighing 20-3,000 g and having a 4-60 mm wall thickness. The process consists of six operations: 1. periodic extrusion and batching of plasticized material; 2. transportation of a batch by a manipulator and pouring it into a mold cavity; 3. closing the mold by a press; 4. holding the mold closed and heated for curing of the material; 5. opening the mold; 6. knocking out the finished product with a lifter and dropping it into a bin. Process analysis with the aid of cyclograms and structural synthesis with the aid of physical models are followed by a cost evaluation, all of which requires a computer for handling a large volume of data and leads to the final choice among all variants under consideration. The procedure is demonstrated on a robotic processing complex with extruder screw and press using automatic manipulators for manufacture of "fiberite" (voloknit) products by optimum coordination of single-position, two-position, and four-position cyclograms characterizing the process operations. Screw presses PVCh-50V, PVCh-63V, PVCh-63VK for processing "fiberite", PVCh-63A for processing "asbomass", and PVCh-63S for processing fiberglass have been designed to fit into this complex. They yield a productivity 2-4 times higher than does existing machinery. Figures 3; references 5 (Russian).

2415/9835
CSO: 1861/213

UDC 621.80

SOLUTION OF INVERSE PROBLEM OF MANIPULATOR POSITIONING BY METHOD OF SCREWS

Moscow MASHINOVEDENIYE in Russian No 1, Jan 86
(manuscript received 25 Dec 84, after completion 28 May 85) pp 36-40

[Article by V.A. Glazunov, Moscow]

[Abstract] The inverse problem of manipulator positioning, namely determining its joint coordinates from the known position of its grip in the

work envelope, consists of solving a system of nonlinear equations. These equations are obtained by multiplication of matrices which describe the coordinate transformations going from one link to the next. The drawback of iterative solution by the Newton-Raphson method is that the number of iterations depends on the initial estimate of the joint coordinates. Sequential determination of the coordinates is in this case preferable, and possible by the method of screws. This method is applied here to manipulators with six kinematic pairs and thus six degrees of freedom. The 3-step procedure involves defining the dual angle $\Delta = \delta + \omega c$ (δ is the angle between axes of kinematic pairs 1 and 6, c is the distance between them, and ω is the Clifford multiplier), next introducing a fictitious four-link analog of the manipulator including an imaginary "link" joining the first pair and the sixth (last) pair and solving a system of trigonometric equations for three coordinates, then determining the other three corrdinates with the position and the orientation of the unit vector along that "link" perpendicular to both the axis of the first pair and the axis of the sixth (last) pair assumed to be known. The procedure is demonstrated on a manipulator with four rotary and two translational pairs, five rotary and one translational pair, and with six rotary pairs. A set consisting of a rotary pair and a translational pair whose axes coincide is treated as a cylindrical pair. Figures 5; references 3: 1 Russian, 2 Western.

2415/9835
CSO: 1861/213

UDC 621.822:669-419.4

ELASTOHYDRODYNAMIC PROBLEM IN THEORY OF LUBRICATION FOR TWO-LAYER RADIAL SLIDING BEARINGS

Moscow MASHINOVEDENIYE in Russian No 1, Jan 86
(manuscript received 23 Apr 85) pp 108-113

[Article by V.N. Prokopyev and A.A. Muravyev, Chelyabinsk]

[Abstract] The problem of bearing lubrication theory and bearing design, namely determining the elastic deformation of surfaces separated by the lubricant film, is solved for a radial sliding bearing on the basis of a model of a two-layer bearing sleeve. The sleeve consists of two coaxial cylindrical layers with different elastic properties, a thin inside layer in contact with the lubricant film and a thick outside layer. The journal is assumed to be rigid. The problem cannot be solved by the direct method for bearings under a load which varies in both magnitude and direction, because the boundaries of the loaded film segment also vary and their location at every instant of time is not known a priori. The problem is therefore solved by the implicit iterative method, its elastic part and hydrodynamic part treated separately and sequentially in each iteration. The procedure continues until the solution for the bearing displacement function and the lubricant pressure function converges sufficiently. The

plane problem of elasticity is treated as a mixed boundary-value problem and its solution, namely the bearing deformation characterized by displacements of the contact surface between the two annular bearing layers, is obtained in the form of a differentiable analytic function. Numerical results for a 5 cm long and 2.17 cm thick bearing with a 10 cm inside diameter on a journal with 200 μm diametral clearance have been obtained with the aid of a YeS-1022 computer, assuming a 0.07 cm thick inside layer and a 2.1 cm thick outside layer. Figures 3; references 3 (Russian).

2415/9835
CSO: 1861/213

UDC 658.2:Δ65.011.56:678.5-419.8:666.189.2

ROBOTIZED PLANT FOR MANUFACTURE OF FIBERGLASS PRODUCTS

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 1, Jan 86 pp 13-15

[Article by G.P. Vinogradov, candidate of technical sciences, S.V. Listov, engineer, A.N. Baloshin, engineer, and Ye.I. Lampe, engineer]

[Abstract] An industrial robot facility is being developed for manufacture of fiberglass products in a single technological cycle with automatic program control. It consists of nine robotized modules. Module RTM1 with a "Universal-60" industrial robot performs operations of counting, stacking, and transporting the laminate sheets. Module RTM2 with two MP20P40.02 industrial robots performs operations of cutting out blanks and batching them. Module RTM3 performs operations of cleaning and greasing the metal pans. A set of 42 RTM4 modules, including a hydraulic press and an MP20P40.02 industrial robot as well as two bins for blanks and processed parts respectively, performs pressing and trimming operations. Modules RTM5, RTM6, RTM7 perform finishing operations for specific products, module RTM5 being equipped with a grinding tool and a "Brig-10" industrial robot as well as a bin. Module RTM8 with a "Brig-10" industrial robot performs drilling and deburring operations. Module RTM9 with an MP20P40.02 industrial robot and a conveyor performs operations of packing, transporting, and storing the finished products. Installation of the entire facility in the Stupino fiberglass manufacturing plant will be completed before 1990. In the meantime, 42 modules are already operating in the press room for products weighing up to 40 kg. Figures 5.

2415/9835
CSO: 1861/126

UDC Δ62-52

AUTOMATIC CONTROL OF CENTER DRIVE IN PARTS MACHINING FACILITY

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 1, Jan 86 pp 22-23

[Article by V.A. Zaderenko, engineer]

[Abstract] A lathe for turning the ends of long round rods from square steel stock is run by an A02-71-14 3-phase induction motor, 22 kW - 1490 rpm, coupled through a V-belt to a gear set in the headstock. An automatic control system has been developed at the Starooskol'skiy machining plant for smoothly stopping the motor (via a combination of mechanical and dynamic effects) and positioning the driver plate so as to facilitate removal of finished rods and insertion of blank bars. It consists of position sensors, two brake electromagnets, three intermediate relays with contactors and diode-resistor circuits, a main relay with shunting capacitor, a time relay, and a transistor switch between both relays. With this automatic control system installed, it should be possible to let automatic manipulators perform the bar insertion and rod removal operations. Figures 3.

2415/9835
CSO: 1861/126

UDC 658.012.011

AUTOMATING ON-LINE CONTROL OF PRODUCTION LINES WITH NC EQUIPMENT

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 1, Jan 86 pp 23-25

[Article by B.S. Shalimov, candidate of technical sciences, and S.B. Shestoperov, candidate of technical sciences]

[Abstract] Automation of on-line control in flexible production systems which use NC equipment is considered from the standpoint of productivity and cost. The problem is treated as one of scheduling and sequencing of operations on a calendar basis, with the maximum possible workload and thus the minimum downtime as criterion of cost effectiveness. The target function in accordance with this criterion is formulated as a double sum of products of downtime X cost factor, over $i = 1,\ldots,D$ different parts and $i = 1,\ldots,N_i$ operations per part. Calculations are made for a typical production line consisting of a lathe for turning all parts and three other machine tools, for face grinding, vertical drilling, and horizontal drilling - not necessarily all required for all parts. Four possible sequencing schemes are compared for the purpose of optimization, by minimization of the production cycle time, and two of them are found to

result in a cycle only 344 h long or 28 h shorter than the cycles based on the other two schemes. Tables 1.

2415/9835
CSO: 1861/126

UDC 532.616.5

DYNAMIC CHARACTERISTICS OF GAS-LUBRICATED THRUST BEARINGS

Moscow MASHINOVEDENIYE in Russian No 4, Jul-Aug 85
(manuscript received 1 Mar 84, after completion 11 Dec 84) pp 95-102

[Article by Ye.G. Grudskaya and Yu.V. Borisova, Leningrad]

[Abstract] Two types of gas-film thrust bearings are considered, a support strip with two symmetric rows of orifices and a support collar with one row of orifices. Their dynamic characteristics, which depend on the transient pressure distribution, are calculated from the solution to the corresponding Reynolds equation for appropriate boundary conditions but not requiring initial conditions in this time-periodic problem. The equation is formulated according to the gasdynamic theory of lubrication, with the number of orifices so large as to approximate a line source. The equation is solved by three methods. The method of lumped parameters, with the pressure at the feeder given by the condition of flow rates balance, yields analytical expressions for stiffness and damping. The method of small perturbations, in the quasi-static version, applies to linear oscillations with small amplitude. Oscillations with arbitrary amplitude, assuming a sufficiently wide clearance, require numerical integration of the Reynolds equation. This is done by approximating it with a finite-difference equation of second-order precision so as to ensure absolute stability of the appropriate implicit scheme regardless of the time and space discretization periods. Damping and stiffness were calculated by each method, also the reaction force of the gas film was calculated by the method of small perturbations and the method of numerical integration. The data indicate the ranges of close agreement and widening discrepancy, which depend on the ranges of eccentricity and squeeze number, different for each type of bearing. Figures 4; tables 1; references 7: 5 Russian, 2 Western (1 in Russian translation).

2415/9835
CSO: 1861/199

UDC 621.01

METHOD OF CORRECTING SPATIAL CONFIGURATION OF BENT PIPE

Moscow MASHINOVEDENIYE in Russian No 4, Jul-Aug 85
(manuscript received 24 Jul 84) pp 42-48

[Article by N.A. Serkov and Ye.I. Pan, Moscow]

[Abstract] The accuracy of bending pipe into complex three-dimensional configurations by NC machine tools can be refined through application of the principles of automatic correction search, treating the pipe as a kinematic chain with positioning errors in its link elements. The configuration of the pipe is defined by four parameters: length of straight segment, bending radius, bending angle, and turning angle of the elbow joint relative to the preceding joint. The method of correction search is implemented with the aid of a calibrated reference tube and a general-purpose or special-purpose coordinate measuring instrument with a computer for optimum control of the assembly jig. The operation proceeds automatically with feedback and use of weight factors accounting for tube size, elasticity of the tube material, and manufacturing tolerances. The program, based on kinematic analysis, is designed to reduce systematic errors of measurement to within acceptable limits and then to minimize deviations of geometrical parameters from the reference. For production, the entire operation of correct tube bending is formulated according to the principles of quality control. Figures 4; tables 1; references 5: 3 Russian, 2 Western.

2415/9835
CSO: 1861/199

UDC 389.14.003.13:658.5:025.4.036:681.2

COST EFFECTIVENESS OF METROLOGICAL CERTIFICATION OF ENGINEERING MEASUREMENT PROCEDURES USING MEASURING AND INFORMATION SYSTEMS

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 1, Jan 86 pp 53-55

[Article by M.F. Natalyuk, Yu.R. Kalitsinskiy and B.D. Kolpak]

[Abstract] The cost effectiveness of the use of measuring and information systems in metrological certification of engineering measurement procedures is evaluated, taking into consideration that certification is based on accuracy and reproducibility of measurements. These requirements are met in four steps: 1. development and adoption of a system of standard technical documentation; 2. establishment of a scientifically-based set of accuracy indicators; 3. designation of scientifically-based inspection periods for the instrument channels of a measuring and information system; 4. development and adoption of optimum techniques of metrological supervision. The cost effectiveness of each step is evaluated from the standpoint of the national economy, with the cost of measurement errors and

the production losses resulting from them as criterion. This was applied to certification testing of a procedure for measuring, with the use of a measuring and information system, the horizontal displacement of semisubmerged floating off-shore oil drill rigs. Calculation of the economic effect [savings] have yielded 649 thousand rubles for step 1, 1,091 thousand rubles for step 2, 231 thousand rubles for step 3, and an overall savings of 1,387 thousand rubles without step 4 but with an additional annual saving of 225,700 rubles as a result of organizational changes with inclusion of quota sharing. References 4 (Russian).

2415/9835
CSO: 1861/205

UDC 621:65.011.56:002.237

NEW INDICATOR OF WORKSHOP PERFORMANCE IN ENTERPRISES WITH AUTOMATIC PRODUCTION CONTROL

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 2, Feb 86 pp 29-31

[Article by V.V. Mikheyev, candidate of economic sciences, Yu.L. Moyzhes, candidate of technical sciences, and F.E. Tochanskiy, candidate of technical sciences]

[Abstract] Qualitative indices for labor synchronization and degree of completion of production-in-progress were defined earlier (MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA No 7, 1983); that article is summarized here. In addition, a new indicator of workshop performances is proposed for evaluation of automatic production control in enterprises. This indicator, a qualitative one, is the degree of synchronization in operations sequencing toward the ultimate goal of final assembly within the scheduled time period. This single indicator is to replace the two qualitative indicators now used for performance evaluation in small-scale enterprises (degree of synchronization in terms of production items and distribution of completed monthly production over the 10-day time segments). Together with the single quantitative indicator now used, namely the percentage of completed production in terms of total labor expended, this indicator should provide a better basis for improvement of the scheduling process and for monitoring the performance of workshops. It allows establishment of production accounting rules such as inclusion of excess production and exclusion of work done on one-short orders from the sales department unrelated to the main production. Use of this new indicator should contribute to a 10-12% reduction of overtime labor in assembly workshops.

2415/9835
CSO: 1861/223

UDC Δ621.3-523.8:002.5:65.011.56

ORGANIZATION OF DATA ACQUISITION FROM VIDEO TERMINALS OF AUTOMATIC CONTROL SYSTEM FOR TECHNOLOGICAL PROCESSES IN PETROLEUM RESHIPMENT PORT

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 2, Feb 86 pp 31-32

[Article by V.G. Voronenko, engineer]

[Abstract] An economical method of data acquisition and processing is proposed for the Ventspils petroleum reshipment port run by the LaSSR State Committee for Petroleum Products, to ensure the necessary speed of response to input polling at any video terminal of its automatic control system. Part of the information is processed at the intermediate level, but all information is stored in a single database with appropriate management within the real-time operating system. The software is organized to allow any functional task to be performed off any terminal without restrictions and, at the same time, to identify the given terminal for later tracing, if necessary, of the source of incorrect or contradictory information. Inquiries are addressed first to the program dispatcher, a resident direct-access memory with all video terminals initially hooked on. In the dispatcher memory are also stored subroutines for processing asynchronous outputs, their number corresponding to the number of video terminals, which include disconnecting a terminal without analyzing the input symbol and only then processing the acquired data till instruction ASTX to stop is issued. An essential feature of the database as its organization into tree structures. Manual input of such structures into the database is organized according to an algorithm which allows data modification, the driver terminal in the real-time operating system being capable of identifying ESC or AP2 sequences of 033_8-code symbols. The software is designed for use with an SM-4 small computer and VTA-2000 video terminals.

2415/9835
CSO: 1861/223

ESTIMATING CHANGE IN LMZ K-210-130 TURBINE EFFICIENCY BETWEEN OVERHAULS

Moscow ENERGETIK in Russian No 1, Jan 86 pp 5-6

[Article by engineers S.V. Rybachkov, Sredaztekhenergo; Ya.D. Berkovich, Sredazenergo; and V.P. Rubtsov, Mary GRES]

[Text] A great deal of attention is now being given to the problem of optimizing turbine operation between overhauls in view of the fact that extensions of operating time between overhauls constitute one of the most important means we have of increasing the efficiency of our thermal power plants. Knowledge of the mean decline in economic efficiency over any given period of time of a turbine placed placed back in operation following overhaul can be of great assistance in determining optimum overhaul schedules for a turbine facility.

Over the period 1979-1983 enterprises of Sredaztekhenergo and Sredazremenergo conducted a series of thermal and quick, operational ["ekspress"] tests on one of the LMZ K-210-130 turbines at the Mary GRES [state regional electric power plant] with the object of determining the quality of the maintenance which had been performed and improving the turbine quick-test procedure. Participating in this program were representatives of the Kharkov branch of the central design offices of Soyuzenergoremont and Belenergoremnaladka.

The objective of these tests was not to gather data for analysis of changes in turbine efficiency between overhauls. But it would make no sense to pass up the opportunity to correlate and analyze the experimental data on operating efficiency between overhauls accumulated over the period 1979-1983 from this particular point of view.

The following tests were performed on the turbine during this period:

February and April, 1979 - quick test prior to overhaul;
July 1979 - quick test following overhaul;
December 1979 - thermal tests and regular quick tests
September 1980, September 1981 and March 1983 - regular quick tests;
July 1983 - combined thermal and quick tests prior to overhaul and
October 1983 - quick tests following overhaul.

The critical parameters on which computations of the technical-economic indicators of turbine operation are based (capacity, pressure, temperature and consumption of medium during thermal testing) were recorded by instruments providing particularly high levels of accuracy (0.5 for the most part) and duplicated by readings on standard instruments which had been tested for the purpose. The number of measurements taken conformed to specifications in the in the instructions.

Equipment operating conditions at the power plant

The power units at the Mary GRES operate under variable conditions. The plant uses natural gas from two separate deposits with a combustion heat of 33.52 MJ/kg (8000 kcal/kg). The plant's direct-flow water-supply system runs on the V. I. Lenin Karakum Canal. Cooling water temperature varies between +5 and 29-30°C.

Prior to the overhaul in 1979 the turbine had operated some 24,600 hours and then another 28,400 hours following the overhaul. The mean load on the turbine between overhauls was approximately 174 MW, the turbine generating a total of 4.94 billion kWh of electric power during the period. Daily loads on the power unit fluctuate between 130 and 210 MW. The plant maintains the following thermal process parameters: live steam pressure - 130 kg/cm^2; temperature of live and reheated steam - 540°C. Actual vacuum ranged between 0.03-0.04 kg/cm^2 in the winter and 0.086-0.09 kg/cm^2 in the hottest part of the year (July and August).

The plant does not operate the power unit with varying live steam pressure ahead of the turbine.

Medium repairs (in February 1981 and June 1982) and routine maintenance (July 1980 and January 1982) had been performed between the overhauls in 1979 and 1983. There were eight emergency shut-downs of the power unit during the period between overhauls, four of these due to problems with equipment in the engine room. There were no problems with the turbine itself.

Changes in the condition of the high-pressure cylinder

Several series of tests involved computation of the efficiency of the high-pressure cylinder with and without regeneration and with both varying and nominal live steam pressures. To permit comparison and analysis of all efficiency test values, Figure 1 shows the change between overhauls as plotted on the basis of a relative efficiency (using the results of 72 tests). The figure for efficiency measured following the overhaul in 1979 has been taken as the nominal value.

It should be pointed out here that the high-pressure cylinder was not opened during the overhaul in 1979, since when it was opened during maintenance performed in 1978 it had been pronounced in satisfactory condition. The increase in efficiency (as determined by the state of the steam ahead of the check valves) observed following the overhaul in 1979 can be explained by the fact that this involved maintenance on the regulating valves (repressing of the seats, replacing the steam screen in the second valve).

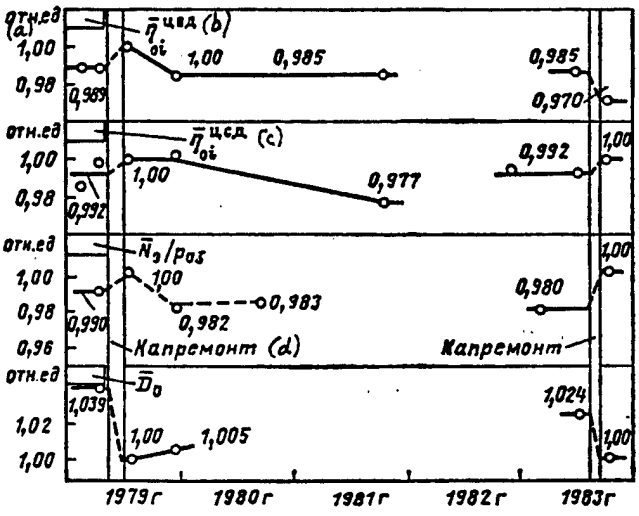

Figure 1. Change in cylinder efficiency and turbine economy based on quick-test data:
$\bar{N}_э/p_{0з}$ - ratio of capacity to pressure in monitoring stage obtained during quick tests. Plotted on the basis of results from 36 tests. $\bar{D}_0$ - live steam flow per turbine. Based on results of 30 tests.
a - relative units; b - high-pressure cylinder; c - medium-pressure cylinder; d - overhaul

Over the course of the first 6 months of operation, the efficiency of the high-pressure cylinder dropped to an initial (preoverhaul) value, where it remained until the next overhaul.

Absolute efficiency in all test series was 2.5-3.5 % abs. lower than standard values. When the cylinder was opened during the 1983 overhaul it was found that the housing of the regulating stage was damaged and that there had been a general degradation of the condition of the entire flow-carrying portion of the cylinder. The housing was then removed, which cut cylinder efficiency another 1.5 % abs. By agreement with LMZ [Leningrad Metal Plant], the turbine was brought back on line without the housing.

Change in condition of Medium-Pressure Cylinder

The curve of the change in the relative efficiency of the medium-pressure cylinder between overhauls (Figure 1) has been plotted on the basis of results from 84 tests. Efficiency computed following overhaul for the corresponding series of tests was employed as the nominal value.

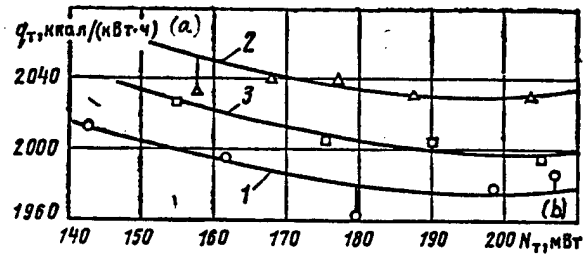

Figure 2. Specific heat consumption in electric power generation:
1 - December 1979, 6 months' operation after overhaul; 2 - July 1983 (before overhaul); 3 - October 1983 (after overhaul); a - kcal/(kW·h); b - MW.

Repairs on the flow-carrying section during the 1979 overhaul increased the economic efficiency of the medium-pressure cylinder some 0.8 % abs. Over the course of the first 6 months of operation, efficiency remained constant and then gradually decreased; over a period of two years it dropped roughly 2%. The overhaul in 1983 resulted in a change in the efficiency of the medium-pressure cylinder of 0.8 per cent, just as did the 1979 overhaul.

Estimating change in actual economic efficiency of turbine

Figure 1 also shows the change in the economic efficiency of the turbine on the basis of data obtained in 36 of the quick tests.

In this case, due to the great difference in the conditions under which the series of tests during the period 1979-1981 were conducted and those obtaining in 1983 (which was the result both of the operating schedule and the condition of the equipment in the power unit), test data obtained following the respective overhauls have been taken to represent the intitial conditions.

The 1979 overhaul (during which the high-pressure cylinder was not opened) resulted in a 1-per cent increase in turbine efficiency. Then over the course of 6 months' operation, turbine efficiency dropped roughly 1.5% and then another 2% over a period of 2.5 years.

After the overhaul in 1983, quick-test data showed efficiency up some 2%, but in fact it was more, what with the fact that the removal of the housing of the regulating stage of the high-pressure cylinder cut overall turbine efficiency by approximately 0.5%.

The overall change in turbine efficiency between overhauls can also be computed on the basis of the change in steam and heat rates for a specific output level. Here all test data (30 tests) obtained in simple thermal tests were adjusted for a single set of conditions (parameters and thermal system).

In view of the fact that tests to determine the turbine's steam and heat rate were conducted only 3 times, it was not considered possible to take this as a basis for constructing the curve of the change in turbine efficiency between overhauls. The overall change in economic efficiency between overhauls was 2.7%, which is comparable with the change in specific fuel consumption for the power unit as a whole. According to data from the plant maintenance office, maximum (summer) specific fuel consumption increased between overhauls by 2%. The overhaul in 1983 improved the condition of the turbine: specific fuel consumption dropped 1.6 per cent (Figure 2).

After analyzing all the experimental data gathered over the period 1979-1983 and operational data on the performance of the power unit, we can evaluate the change in turbine efficiency as follows:

— the change in efficiency during the overhaul in 1979 (in which the high-pressure cylinder was not opened) was roughly 1%;
— the efficiency of turbine operation between overhauls (28,400 hours) was degraded by 2.5-2.7%;
— the complete overhaul of the turbine in 1983 produced a change in efficiency of 1.6-2 per cent, but in fact the change was even greater, what with the fact that operation without the housing on the regulating stage of the high-pressure cylinder reduces the overall economic efficiency of the turbine by roughly 0.5%.

8963
CSO: 1861/93

UDC 629.7.067.5

DETERMINATION OF TEMPERATURE OF INLET GUIDE VANE SURFACE IN AXIAL COMPRESSOR TO PREVENT ICING

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 3, Jul-Sep 85 (manuscript received 12 Aug 84) pp 51-55

[Article by V.N. Osipov]

[Abstract] For the purpose of preventing ice formation on the surface of inlet guide vanes in an axial compressor, the temperature and the anti-icing characteristics of that surface are determined from the corresponding equations of heat balance and heat transfer at a vane surface in a stream of wet air. Assuming invariant boundary conditions for air outside and inside, no heat transfer across joints in the vane structure, and a heat transfer at the surface of vanes which does not depend on the hydrodynamics of internal flow, the problem can be solved analytically and has been solved for inlet guide vanes to be protected against icing by heating of the internal air. Icing is particularly imminent at high air velocities (30-50 m/s) under high pressure, with an absolute air humidity exceeding 1 g/m^3 and with a moisture entrapment factor as high as 0.98 at subzero temperatures. Semiempirical relations in the $Nu = kRe^mPr^n$ form have been established for both the entering air and the water equivalent of the heating air in this case so that the surface temperature of a heated vane in wet air or in dry air can be calculated for any distribution of circulating hot air and for any mode of compressor operation. Figures 4; references 2 (Russian).

2415/9835
CSO: 1861/110

UDC 533.6.011.3:629.7.036.3

DEPENDENCE OF FLOW PATTERN IN DIFFUSER ON VELOCITY PROFILE IN ENTRANCE SECTION

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 3, Jul-Sep 85 (manuscript received 28 Mar 85) pp 70-74

[Article by A.A. Turilov and G.M. Shalayev]

[Abstract] An experimental study of flow patterns in diffusers for combustion chambers and after burner chambers of two-loop gas turbine engines was made, such diffusers being characterized by a nonuniform velocity profile in their entrance section. This velocity profile is determined either by the thickness of the boundary layer and the trail behind the compressor blades in the case of combustion chambers or by the mixer design in the case of afterburner chambers. Two basic mixing devices were considered for afterburner chambers, a paddlewheel mixer and a throw-over of air from the outer loop into the gas stream in the inner loop, in addition to a diffuser without mixer. The results reveal that a diffuser without special mixing device, besides being characterized by a simpler construction and lower hydraulic losses, features a quicker flattening of the velocity profile and thus a more uniform flow pattern downstream in addition to a better recovery of the static pressure. Figures 5; references 7: 3 Russian, 4 Western.

2415/9835
CSO: 1861/110

UDC 621.822

OPTIMUM RELATION BETWEEN ELASTIC AND DAMPING COMPONENTS OF ROTOR BEARINGS

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 3, Jul-Sep 85 (manuscript received 28 May 84) pp 74-78

[Article by D.Ye. Chegodayev]

[Abstract] A simple rotor symmetric with respect to the plane through its center cross-section is considered running on two identical bearings symmetrically spaced on both sides. Its vibrations under a harmonically varying centrifugal force are analyzed on the basis of a system of two equations for two dynamic models: a mass supported on either a series-connected spring and (parallel) spring-plus-dashpot system, or on a parallel-connected spring and (series) spring-plus-dash pot system. The solution yields the relation between the damping coefficient and the ratio of the two stiffness coefficients for optimum damping in any particular rotor-bearings configuration and for tuning to any mode of rotor-bearings dynamics. The results of this analysis are applicable to rotors of gas turbines and turbogenerators as well as for rotors in machine tools. As

an example are shown the relations for a flexible rotor on hydrostatic bearings. Figures 3; references 6: 5 Russian, 1 Western.

2415/9835
CSO: 1861/110

UDC 621.438

SOME FEATURES OF FLOW ALONG TURBINE BLADES WITH FILM COOLING

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 3, Jul-Sep 85 (manuscript received 18 Mar 85) pp 96-98

[Article by V.K. Milovanov]

[Abstract] An experimental study of flow along the blades of gas turbine engines with air film cooling has revealed a possibility of circulation flow in both the profile plane and in the meridional plane. This happens when the sum of gas flow rate and cooling air flow rate exceeds the critical coolant flow rate, with the ratio of cooling air flow rate to total air injection rate depending largely on the angle of attack and hardly at all on the velocity. An analysis of the circulation flow in both planes on the basis of the respective pressure distribution curves indicates that local circulation is possible along the back edge as well as within the channel, but also that the flow of the cooling air film is most stable along the back edte. Figures 3; references 3 (Russian).

2415/9835
CSO: 1861/110

UDC 629.7.036.3:621.43.056

MEASUREMENT OF SOOT EMISSION FROM COMBUSTION CHAMBER OF GAS TURBINE ENGINE

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 3, Jul-Sep 85 (manuscript received 12 Sep 84) pp 100-102

[Article by O.V. Strogonov, V.S. Varfolomeyev, A.D. Dekhtyarenko, A.V. Shchukin, B.G. Mingazov and Yu.P. Marchukov]

[Abstract] Measurements of soot emission from the combustion chamber of aircraft gas-turbine engines were made, as a monitoring procedure for environmental protection in critical locations such as airports. An experimental combustion chamber was built in the form of an annular compartment containing three burners and having a single row of orifices for injection of secondary air into the furnace flue. Primary air under nearly atmospheric pressure and TS-1 kerosene fuel were injected into the

mixing chambers by an array of paddle whirlers and an array of centrifugal nozzles respectively. The soot emission level and the smoke number were measured by the filtration method, without cooling of the injection zone. The data reveal that the soot concentration along the primary zone of the combustion chamber rises to a maximum at a distance from the mixing chamber exit equal to one bore diameter of the whirler array and then drops sharply toward the orifices in the furnace flue. Changing both outside and inside diameters of the whirlers was found to have almost no effect on the soot concentration in the throat of the combustion chamber but an appreciable effect on the soot concentration along the primary combustion zone. As the air velocity at the entrance to the combustion chamber and thus also the air velocity through the orifices in the furnace flue was increased, the soot level dropped and the smoke number became less dependent on the excess air factor, although still dropping to a minimum of 1.5-2 at 3.5 excess air. Figures 3; tables 1; references 1 (Russian).

2415/9835
CSO: 1861/110

UDC 539.3

DESIGN OF HEAD OF AUTOMOBILE ENGINE PISTON FOR DISCRETE STRENGTH EQUALIZATION

Moscow MASHINOVEDENIYE in Russian No 4, Jul-Aug 85
(manuscript received 5 Apr 83, after completion 19 Nov 84) pp 66-70

[Article by V.P. Malkov, V.P. Povelikin and O.N. Tolstokulakova, Gorkiy]

[Abstract] A finite-elements procedure for optimal design of piston heads of internal combustion engines is proposed which will result in an economical distribution of material and ensure a uniform distribution of stresses. The necessary stress and strain analysis involves solution of an axisymmetric free-body problem of steady-state thermoelasticity. In this case the problem splits into two: 1) problem of heat conduction in the given configuration with given temperature boundary conditions; 2) problem of elasticity in displacements and stresses under given mechanical actions in the established temperature field. Both are solved on the same grid of finite elements; linear thermal expansion is assumed to be isotropic within each finite element. Discrete equalization of strength is then attained by iterative variation of stresses in discrete regions, through successive redistributions of the material in terms of thickness adjustments. The procedure was tried on the design of a typical piston, for discrete strength equalization under typical operating conditions. A head of optimally variable thickness not smaller than the permissible minimum weighed in this particular case 32% less than a head of uniform thickness for the same performance requirements. Figures 3; references 10 (Russian).

2415/9835
CSO: 1861/199

UDC 621.822.5

EFFECT OF STRUCTURAL FACTORS ON PERFORMANCE OF AXIAL BEARINGS DURING LONGITUDINAL VIBRATIONS OF TURBINE SET FOUNDATIONS

Moscow MASHINOSTROYENIYE in Russian No 4, Jul-Aug 85
(manuscript received 14 Nov 83, after completion 26 Nov 84) pp 77-81

[Article by I.Ya. Tokar and B.P. Kalinin, Kharkov]

[Abstract] For a performance evaluation of axial thrust bearings in turbine sets during seismic activity and resulting vibrations of the foundation, the response of lubricant films (non-isothermal approximation) in both left-hand and right-hand bearing rows is calculated from the solution of the corresponding transient-flow Reynolds equation. Assuming a zero initial temperature gradient across the film thickness, the results indicate that the minimum thickness decreases appreciably with increasing axial play in the runner structure, decreases slightly with increasing stiffness of the foundation structure, increases slightly in the left-hand row and decreases slightly in the right-hand row with increasing steam pressure, and increases as the width-to-length ratio B/L of bearing segments is increased. The oil temperature rise is found to decrease as this ratio is increased. An adequately earthquakeproof bearing, typically with N = 8 segments and ϵ = 7% eccentricity, should be designed with B/L $\geq$ 1.2, but making this ratio larger than 1.5 will not appreciably improve the performance. The numerical data are based on forced vibrations at a frequency of 8.33 Hz and a lowest of the natural frequencies equal to 48.3 Hz. A comparison with the isothermal approximation indicates that the latter yields almost the same runner displacements but an erroneously much larger smallest minimum film thickness. Figures 5; tables 1; references 1 (Russian).

2415/9835
CSO: 1861/199

UDC 621.436:629.12

HIGH-ECONOMY DIESEL ENGINES FOR SHIPS

Leningrad SUDOSTROYENIYE in Russian No 11, Nov 85 pp 16-20

[Article by L.P. Sedakov and F.M. Yelistratov]

[Abstract] The worldwide trends in development, design, and manufacture of high-economy low-speed marine diesel engines since the 1960s are reviewed, high efficiency and low weight-to-power ratio at optimum mean and supercharge pressures being important considerations along with fuel and lubricant economy. Outstanding contributions to the state of the art are MAN "B or W" series L-GB (L-GBE) and L-MC (L-MCE) as well as their Soviet equivalents. Noteworthy is the improvement of the fuel economy (based on

42,707 kJ/kg) in the present tenth-generation diesels to approximately one half of fuel g/kW from what it was in the seventh-generation (1980) diesels. Noteworthy is also attainment of overall efficiencies above 50%. Low-speed marine diesels now produced cover the 1200-44,000 kW range of power ratings. Figures 4; tables 2; references 7: 2 Russian, 5 Western.

2415/9835
CSO: 1861/140

UDC 535.214.4:533.6.07

RADIOMETRIC APPARATUS FOR OPTICAL MEASUREMENTS ALONG BALLISTIC PATH

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 3, May-Jun 85
(manuscript received 19 Jan 84) pp 155-158

[Article by Ye.P. Andreyev, N.N. Baulin, A.M. Biryukov, V.L. Grenkov, A.M. Daushvili, D.S. Yermakov, D.G. Kuvalkin, V.A. Lyutomskiy, I.N. Orlova, N.N. Pilyugin, Yu.M. Sagaydachnyy, O.K. Taganov and A.S. Trufanov, Institute of Mechanics, Moscow State University]

[Abstract] A radiometric apparatus for measurements of radiation in the region emanating from an object in hypersonic flight along a ballistic path is described; its two main instruments being a 2-channel pyrometer-lucimeter with an illuminating light source and a wide-angle IR radiometer. The two photoreceiver channels in the pyrometer-lucimeter utilize FS-36DA InSb photoresistors with a 1 μs time constant to measure radiation from the bow shock and wake regions on two different wavelengths. The output signals appear on a 2-channel S8-11 storage oscilloscope. The illuminating light source is used in conjunction with the pyrometer-lucimeter to measure absorbance in the wake and emissivity; the IR radiometer is used to measure the intensity and luminance (after filtering). Measurements were made on an experimental stand in which two spherical copper-clad duralumin projectiles were hurled through a cylindrical compartment, one 8.0 mm in diameter with No 88 synthetic adhesive coating and polyethylene jacket at a velocity of 2038 m/s into a mixture of 25 torr air + 15 torr xenon, and the other 5.3 mm in diameter bare at a velocity of 9.7 Mach into a mixture of 30 torr air + 35 torr xenon. Figures 3; references 10: 8 Russian, 2 Western (1 in Russian translation).

2415/9835
CSO: 1861/121

UDC 537.533.73

METAL-AND-GLASS LOW-VOLTAGE ELECTRON DIFFRACTOMETER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 3, May-Jun 85
(manuscript received 29 Apr 84) pp 176-178

[Article by S.A. Knyazev and Yu.B. Vymorkov, Leningrad Institute of Electrical Communications Engineering]

[Abstract] A metal-and-glass electron diffractometer is described, a combination of spherical glass chamber and a metallic manipulator, which not only allows the complete coverage of the diffraction pattern of slow electrons but also manipulation of the crystal inside the diffraction chamber and movement of the photometer outside. The manipulator is placed coaxially with the electron gun and coupled to the glass chamber through a bellows. A luminescent screen with a conductive coating covers the front part of the inside surface of the glass chamber, and an Alpert lamp and orbitron pump are soldered to diametrally opposite lateral protuberances. The electron-optical system consists of an electron gun with a LaB_6 cathode delivering a current of 1 μA and two concentric molybdenum-fiber grids subtending a solid angle of almost 4π sr. Bending of the bellows by three screws 120° apart causes the glass sphere to move relative to the crystal holder about 5 mm in any direction, while the crystal in the holder can be rotated about two mutually perpendicular axes by bending of another bellows with a control knob. The two rotations, through $\pm 50°$ about the vertical axis and through $\pm 20°$ about the horizontal axis, are not mutually independent but the latter is intended only for minor adjustments. A fine crystal surface finish can be produced by cleaving in a vacuum of $2 \cdot 10^{-9}$ torr with a scissors mechanism. The crystal can be heated by a furnace behind or cooled with liquid nitrogen so that its temperature, measured with a molybdenum-Kovar thermocouple, can be varied over the 170-900 K range. The intensity of diffracted electron beams is determined from the brightness of the luminescent screen, measured with a photometer. The diffractometer has been successfully used for several years, mainly for determining the energy and temperature distributions of 25-100 eV electrons diffracted by surfaces of alkali-halide crystals. Figures 2; references 6: 4 Russian, 2 Western.

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UDC 535.8:535.242.2

HIGH-SPEED PRECISION PHOTOMETER FOR AUTOMATIC MICRODENSITOMETER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 6, Nov-Dec 85
(manuscript received 25 Jun 84) pp 157-160

[Article by M.P. Grishin, Sh.M. Kurbanov, T.A. Svyatoslavskaya, N.L. Svyatoslavskiy and Ye.I. Chernov, Institute of Terrestrial Physics, USSR Academy of Sciences, Moscow]

[Abstract] A direct-reading photometer is described which can measure the optical density (transmission coefficient) of black-and-white images over the range 0-4 or of color images over the range 0-2.5 to within 1 percent accuracy at a speed of 10,000 readings per second. It operates with luminous flux density 10 times higher than for existing automatic microdensitometers AMD-1 (USSR) and MD-6 (UK), a DKs Sh-150-1 xenon-arc lamp of 300 millinit brightness being used as light source. The optical part of the instrument is built according to the conventional 2-beam scheme, with a measuring channel and a reference channel; an interference filter may be inserted for photometry of color images. The reference channel is built with a light pipe which transmits light from the source to one of the two photoreceivers in the signal processor. The other photoreceiver, at the end of the measuring channel, consists of a photodiode operating in the short-circuit mode and a current amplifier with a gain of 100. A negative-feedback loop around the amplifier ensures high output impedance (>10^9 ohms). The signal processor includes op amps which generate an output signal proportional to the optical density (transmission coefficient), a 0-$\pm$5 V sampler-storage device with a 2.5 μs sampling rate and a $\pm$10 V analog-to-digital converter with 8 μs conversion time to 11-digit word length. Figures 5; references 7: 5 Russian, 2 Western (1 in Russian translation).

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UDC 531.715

DETERMINATION AND AUTOMATIC REGULATION OF OPTICAL THICKNESS OF SCANNING FABRY-PEROT INTERFEROMETER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 6, Nov-Dec 85
(manuscript received 8 Jan 85) pp 144-147

[Article by Yu.V. Yevdokimov, L.L. Kravchinskiy, and M.B. Shtenger, State All-Union Scientific Research Institute of Analytical Chemistry, Leningrad]

[Abstract] The possibility of determining and automatically regulating the optical thickness of an interferometer is examined for the specific case of a scanning Fabry-Perot interferometer. The device works by scanning the

optical thickness of the interferometer itself, and counting the number of shifted interference maxima. Light of two wavelengths from a filtered VSB-2 spectral lamp is incident on the interferometer, and the interference pattern produced by two independent sets of rings, is focused by a lens on the photocathode of an FEU-48-3 photomultiplier. A feedback signal scans the optical thickness of the interferometer and modulates the interference pattern, this interference pattern then producing variations of the electric signal at the photomultiplier output. These variations are analyzed by a preconverter which includes frequency-marker generator. The preconverter output signal passes through a set of binary counters to a D3-28 computer and from here, through a digital-to-analog converter, is added to the ramp-voltage signal for feedback to the piezoelectric cell of the interferometer. With the mercury isotopes $^{198}Hg + ^{204}Hg$ filling the lamp (λ_1 = 5460.740 Å and λ_2 = 5460.765 Å) the optical thickness can be determined within $\pm$0.04 percent and regulated over the 973-29,800 μm range. With the mercury isotope ^{199}Hg filling the lamp (λ_1 = 5460.740 Å and λ_2 = 5460.968 Å) the range is 107-3270 μm and with sodium vapor filling the lamp (two D-lines) the range is 5-148 μm. Figures 3; references 3: 1 Russian, 2 Western.

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UDC 621.317.421.08:537.312.62

INSTRUMENTS FOR MEASUREMENT OF ALTERNATING MAGNETIC INDUCTION AT CRYOGENIC TEMPERATURES AND THEIR METROLOGICAL QUALITY ASSURANCE

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 1, Jan 86 pp 30-31

[Article by D.R. Vasilyev, Yu.I. Kazantsev, S.V. Rypalev and G.K. Yagola]

[Abstract] Design and performance evaluation of cryogenic electrical machines requires measurement of alternating magnetic fields of 0.001-2 T over the frequency range 20-1000 Hz at temperatures of 4.2-293 K. Hall probes of the PKhE class for these ranges of magnetic induction and frequency are, at the nominal control current of 100 mA, adequately sensitive (0.06-0.13 V/T), reliable, and stable under repeated thermal cycling. Their conversion characteristics are linear within 0.1-1% and their temperature coefficient of frequency is $\pm(1\cdot10^{-4} - 3\cdot10^{-3})$%/K. They are also sufficiently small to fit into air gaps not wider than 2 mm and not larger than 5x10 mm^2. For calibration and inspection of instruments used in the field, there have been developed a teslameter with PKhE Hall probes andaa reference electromagnet with standard gages. Minimum waveform distortion and minimum nonlinearity are ensured by energizing the electromagnet with a sinusoidal voltage of stable amplitude through a power amplifier with feedback from the main measuring coil located near the air gap. The gages are solenoids wound with 28 insulated strands of superconducting ultrapure aluminum 0.1 mm in diameter. A dewar flask (outside diameter of 16 mm) fits inside the

solenoid (inside diameter of 26 mm). The solenoid, inside a helium cryostat, is connected in series with a capacitor bank of 320 μF at the resonance frequency of 50 Hz and energized from an audio-frequency oscillator through a 100 W power amplifier with transformer output. Such a gage reproduces alternating magnetic fields with an induction amplitude up to 0.75 T at 100 Hz and up to 0.15 T at 1000 Hz. The complete set can be used for certification testing of cryogenic induction meters. References 4 (Russian).

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UDC 533.6.011.32:532.526.5

AERODYNAMIC AIRFOIL DESIGN FOR NONSEPARATION FLOW

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 3, Jul-Sep 85 (manuscript received 12 Sep 84) pp 47-50

[Article by Z.Kh. Nugmanov, V.A. Ovchinnikov and V.G. Pavlov]

[Abstract] An airfoil is synthesized for a given pressure distribution over its surface, in accordance with the theory of potential flow of an incompressible fluid. Its profile is described by a Jacobi polynomial series so that a properly selected weight function will ensure a closed contour for a given type of edge, and constraints on other geometrical characteristics to ensure nonseparation flow can be imposed by stipulation of some series coefficients. The velocity distribution around the airfoil contour is assumed to be known and the pressure rise within the zone of dropping velocity should yield a subsonic high-lift airfoil. The procedure, with the algorithm programmed for computer calculations, has been applied to synthesis of airfoils with round edges and of airfoils with sharp edges. Changing the shape or the ordinates of the two edges, leading and trailing, while maintaining a given pressure profile was found to shift the crunode. Figures 2; references 6: 4 Russian, 2 Western.

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CSO: 1861/110

UDC 553.601.1

ASYMPTOTIC MODELS WITH FIRST AND SECOND APPROXIMATIONS DESCRIBING INTERACTION OF TWO STREAMS DURING SUPERSONIC FLOW AROUND BODIES WITH INJECTION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 22, No 1, Jan 86 (manuscript received 22 May 84) pp 99-104

[Article by S.I. Blokhin and A.P. Komashenko, Kiev University]

[Abstract] Supersonic flow around a thin body and concurrent injection through the surface are analyzed by the asymptotic method with second-order

corrections supplementing the corresponding system of equations of gas dynamics in the first approximation. In the latter the mixing layer was replaced by a contact discontinuity surface and the flow far from the front edge was treated as that of a nonviscous incompressible fluid describable by thin layer equations, while at the front edge moderate injection became intense. Now the system of the Navier-Stokes equations, continuity equation, and energy equation is solved for boundary conditions at the plate edge and at "infinity" with only moderate injection, and thus also defining a relative thickness of the injection zone. The injected gas is still nonviscous and its flow is isentropic, but the Buseman correction is added and made either equal to or larger than the correction for the finite thickness of the mixing layer. The system of equations in this second approximation, with balance of mass and momentum, is essentially the same in both cases but the boundary conditions are simpler in the latter case. It has been solved by numerical integration on a YeS-1052 computer for zero-value initial conditions. With the distributions of stream velocity components and gas density obtained as a result, their orders of magnitude are estimated in ranges where either viscosity and transverse pressure gradient along with the Buseman correction or thickness of the mixing layer are dominant. Figures 3; references 7: 5 Russian, 2 Western.

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UDC 531

ROTATION OF SYMMETRIC SOLID BODY IN MEDIUM WITH SQUARE-LAW RESISTANCE ABOUT STATIONARY POINT

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 22, No 1, Jan 86
(manuscript received 17 Jul 84) pp 123-126

[Article by V.A. Kuryakov, Perm Commanding Officers' and Engineers' Higher School of Rocket Forces]

[Abstract] Rotation of a symmetric solid body in a resisting medium about a stationary point is analyzed, assuming a speed so high that the moment of forces becomes small relative to the kinetic energy and thus the change of kinetic energy per revolution becomes negligible. The resistance of the medium is assumed to be proportional to the angular velocity of the body squared. The corresponding system of Euler equations is solved by the method of averaging with respect to the fast angular variable, with dissipation taken into account. The evolution of Euler-Poinsot characteristics is found to depend on the ratio of dissipation coefficients α_1 and α_2. Figures 3; references 10: 7 Russian, 3 Western (2 in Russian translation).

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MECHANICS OF SOLIDS

UDC 539.3

PROPAGATION OF NONAXISYMMETRIC ELASTIC WAVES THROUGH ISOTROPIC MULTILAYER CYLINDER

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 22, No 1, Jan 86
(manuscript received 12 Jul 84) pp 111-114

[Article by A.Ya. Grigorenko and T.L. Yefimova, Institute of Mechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] Propagation of generally nonaxisymmetric elastic waves through an isotropic multilayer cylindrical shell is analyzed on the basis of the three-dimensional theory. The corresponding system of three partial differential equations of motion in components of the stress tensor is first expanded into a system of six partial differential equations with the stress components expressed through components of the displacement vector and their gradients, and then reduced to a system of ordinary differential equations in matrix form. The solution is sought in the form of longitudinal travelling harmonic waves with a harmonic circumferential displacement distribution. Stresses are normalized dimensionally to the modulus of elasticity and the radial coordinate, also to the density of material. Numerical calculations by the method of discrete orthogonalization as well as by the $\Delta(\lambda)$-method have been made and dispersion curves have been obtained for boundary conditions at both inside and outside surfaces of a piecewise homogeneous triple-layer structure under no load with ideal interlayer contact, stipulated in terms of third-unit and null matrices. For accuracy control, results obtained for the axisymmetric case have been compared with those obtained by N.E. Keek and A.E. Armenacas in J. ACOUSTICS SOCIETY AMER. Vol 49, No 5, 1971. Figures 2; references 4: 2 Russian, 2 Western.

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UDC 539.3

NONLINEAR CHARACTERISTICS OF WAVE PROPAGATION THROUGH SOLID BODIES WITH INITIAL STRESSES

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 22, No 1, Jan 86
(manuscript received 31 May 84) pp 7-12

[Article by O.I. Gushcha, Institute of Electric Welding, and F.G. Makhort, Institute of Mechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] Propagation of shear waves in materials is analyzed, taking into account the peculiar stress dependence of their velocity, viz., the velocity of shear waves polarized in the direction of load action decreases with increasing tensile stress and increases with increasing compressive stress, and the velocity of transverse polarized shear waves changes less and linearly with increasing load in some materials. The theoretical analysis of these relations is based on the corresponding equations of acousto-elasticity, in the linear approximation with both second-order and third-order moduli of elasticity included. The ratio of these two moduli, which represents the difference quotient of the velocities of longitudinal- and transverse-polarized shear waves, serves as a quantitative measure of non-linearity. After experimental data on various steels, aluminum alloys, and a titanium alloy have been interpreted according to this theory and numerical values of the relevant parameters have been calculated from known characteristics of these materials, an attempt is made to solve the inverse problem of determining stresses in a material from measured velocities of elastic waves propagating through it. Since in practice these velocities cannot be measured precisely, monitoring of their time characteristics must suffice. Results obtained with use of the pulse reflection frequency, inverse of the pulse travel time, in the ultrasonic range of shear wave velocities indicate that the ratio of second-order and third-order moduli is a reliable indicator of nonlienarity in structural materials. Figures 3; tables 5; references 3: 2 Russian, 1 Western.

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DEFORMATION AND FRACTURE OF PLATE UNDER THERMAL SHOCK

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 286, No 1, Jan 86
(manuscript received 20 Mar 85) pp 103-106

[Article by V.N. Aptukov and A.A. Pozdeyev, corresponding member, USSR Academy of Sciences, Institute of Mechanics of Continuous Media, Ural Science Center, USSR Academy of Sciences, Perm]

[Abstract] Wave processes causing deformation and defects in macrofracture zones in a solid under thermal shock are analyzed on the basis of a

two-dimensional axisymmetric model for a thermoelastic and viscoplastic continuous medium with internal state variables. The corresponding system of three (coupled) equations is formulated in terms of stress and strain tensors, taking into account heat capacity and thermal expansion as well as the kinetics of deformation and defects. The problem, which combines these euqations with differential laws of mass and momentum conservation, has been solved for a plate of D16 aluminum alloy. The solution was obtained by using an explicit finite differencing scheme and pertinent experimental data for this material. The solution reveals a possible cumulation of tensile stresses, even in a plate heated uniformly throughout, its magnitude depending on the geometry of the plate and its heated region as well as on the space distribution of the heat sources. A one-dimensional model would not reveal this effect with the attendant cumulation of stress waves resulting in development of macrocracks and formation of free surfaces inside the material, which leads to fracture. Figures 4; references 14: 12 Russian, 2 Western (1 in Russian translation).

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UDC 536.48

CRYOSTAT FOR NUCLEAR DEMAGNETIZATION AND HIGH-PERFORMANCE CRYOSTAT FOR DISSOLVING ^3He IN ^4He

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 3, May-Jun 85
(manuscript received 20 Dec 83, after revision 1 Oct 84) pp 185-192

[Article by A.S. Borovik-Romanov, Yu.M. Bunkov, V.V. Dmitriyev, Yu.M. Mukharskiy, Institute of Physical Problems, USSR Academy of Sciences, Moscow]

[Abstract] Two cryostats have been developed and built at the Institute of Physical Problems, one for dissolving ^3He in ^4He and precooling the other which is for nuclear demagnetization. The continuous-operation dissolution cryostat is of conventional design, with pumps that can circulate helium at a rate of $2 \cdot 10^{-3}$ mole/s under a pressure head of $2 \cdot 10^{-2}$ torr. The purifier consists of a nitrogen trap and a helium trap operating independently. Special features include a helium Dewar flask with liquid-nitrogen shield, a relief valve for dumping ^3He into reservoirs for storage during shutdown of ^3He circulation, and a suspension with bellows and dampers for vibration-proofing. The temperature in the cryogenic chamber, measurable with a nuclear-magnetic-resonance thermometer has been found to obey the relation $T_{ms}^2 = 6.4R_KT^3\dot{\nu}/\sigma + 1.22 \cdot 10^{-2} \cdot Q/\dot{\nu}$ during continuous heat transfer at optimally configured surfaces, the first term with R_KT^3 (Kapitsa resistance) and σ (surface area of heat exchangers) representing the heat of recirculation and the second term with $\dot{Q}$ (rate of heat supplied) representing the heat of dissolution. An efficiency of 15% is theoretically attainable with $R_KT^3 = 0.05\ m^2 \cdot K^4 \cdot W^{-1}$ and correspondingly 1.5 m^2 effective area of heat exchanger surface, but a surface area one order of magnitude larger is required for technological reasons. The demagnetization cryostat contains three copper disks with sintered silver powder coatings of 300 m^2 total theoretical surface area, a thermal switch consisting of 30 wires (99.99% pure lead) 0.5 mm in diameter and 10 mm long between two copper plates, a cooler conduit consisting of copper strands, a superconducting main solenoid, and a plain solenoid maintaining the magnetic field in the He^3 chamber. The nuclear demagnetizer consists of 267 copper conductors, each having 8 strands of the same wire as those of the coller conduit. Each cryostat is surrounded by a thermal shield of stainless steel with a 10 μm thick electrolytically deposited copper coating slit into annular segments.

Characteristics of Cryostat	I.Ph.P. USSR Acad. Sc. 1982	Ohio USA 1979	Cornell USA 1980	Bell Labs USA 1980	Berkeley USA 1979	Grenoble France 1978	Sussex UK 1981
Cooling power of dissolution cryostat, W	$100T^4$	-	-	$10T^4$	-	$100T^4$	
Copper content, moles	13	40	21	15	9	8	15
Wire diameter, mm	0.5	0.18	0.5	0.2	0.23	0.6	0.5
Precooling Temperature, mK	15	27	19	16	19	7	20
Mean magnetic field intensity in demagnetizer stage, T	7.5	7.7	7	6.7	8	8	8
Material of heat exchanger in ^3He chamber	Ag	Pd	Cu	Ag	Ag	Ag	Cu
Grain size, nm	100	2000	30	100	70	40	1000
Surface area of heat exchanger, m^2	10	25	107	100	40	60	8
Lowest attainable ^3He temperature, mK	0.42	0.4	0.34	0.22	0.48	0.4	0.7
Total heat influx to demagnetizer stage, nW	3.1	5.3	-	1.4	3.5	100	3.5

Figures 8; tables 1; references 11: 3 Russian, 8 Western.

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PULSED SOURCE OF CARBON PLASMA FOR TECHNOLOGICAL APPLICATIONS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 3, May-Jun 85 (manuscript received 9 Apr 84) pp 146-149

[Article by A.I. Maslov, G.K. Dmitriyev and Yu.D. Chistyakov, Moscow Institute of Electronic Engineering]

[Abstract] A source of carbon plasma with a pulse-current plasma accelerator has been developed and experimentally built for various technological applications such as deposition of wear-resistant adamantine carbon coatings on tool bit surfaces or on certain electronic components. The source consists of a cylindrical MPG-6 graphite cathode 30 mm in diameter and an annular graphite anode with a 110 mm inside diameter placed in a vacuum chamber, with an annular auxiliary electrode around the cathode tip drawing an energy of 10 J for reliable ignition of a high-current arc in vacuum and a solenoid around the anode for focusing the plasma beam by means of current pulses. The solenoid is connected to the main-discharge circuit so that its magnetic field builds up in synchronism with the accelerator current pulses. The main 2000 μF capacitor bank has voltage regulation over the 100-500 V range and regulation of repetition rate over the 0.1-35 Hz range. This device was experimentally used for carbon coating of metal, silicon, pyroceramic, and glass substrates under a residual pressure of $1 \cdot 10^{-3}$ Pa at temperatures of 50-150°C. The mean energy of carbon ions as function of the discharge voltage was measured with a calorimeter and with a torsion pendulum, the former reading consistently higher values. The coating condensation rate was found to decrease from the center outward and the coating deposition rate was found to decrease with increasing distance from cathode to substrate. The space characteristics of the plasma beam were determined from the radial profile of the coating thickness, on the basis of a special color chart for carbon films. Most importantly, this is a high-stability device with the coating deposition rate changing very slowly in time: with hardly any decrease after the first 10^3 discharges and only a slight decrease after 10^5 discharges. Figures 7; references 8: 6 Russian, 2 Western.

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TWO MODES OF PLASTIC DEFORMATION IN GLASSY POLYMERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 286, No 1, Jan 86
(manuscript received 1 Feb 85) pp 135-139

[Article by E.F. Oleynik, S.N. Rudnev, O.B. Salamatina, S.I. Nazarenko and G.A. Grigoryan, Institute of Chemical Physics, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study was made pertaining to plastic deformation in glassy polymers, to verify the possible coexistence rather than mutual exclusiveness of two deformation modes: reversible large-strain deformation with participation of the entropic force and small-strain deformation with localized nucleation and multiplication of "dislocation analogs" near the upper yield point. Experiments were performed with atactic polystyrene, also with dense-interlinkage epoxy. The temperature dependence of the specific heat $c_p(T)$ was measured by the method of differential scanning calorimetry, along with the temperature dependence of the rate of dimensional recovery and the dependence of the percentage recovery on the residual strain in each mode, after deformation by uniaxial tension, by hdyrostatic compression, and by shear. The results reveal no $c_p(T)$-anomaly after deformation by tension or compression above the glass transition point, incidating absence of dilatation, and a strong endothermal $c_p(T)$-anomaly after deformation by shear. The definite relation between deformation temperature and anomaly temperature, the latter always lagging behind the former, indicates low-energy shear defects fast annealing at the deformation temperature and a wide energy spectrum of glissile defects with a wide range of relaxation activation energy. A weak endothermal $c_p(T)$-anomaly has also been observed after lengthy storage and attendant relaxation of deformed specimens. In glassy polymers under load, accordingly, at deformation temperatures and strain rates in certain ranges some deformation is caused by small-scale slip with a "change of neighbors" and some deformation includes conformative restructurization of chains. Figures 4; references 15: 7 Russian, 6 Western.

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UDC 537.533+537.181+541.183

ELECTRON WORK FUNCTION OF METAL SURFACES COVERED WITH ADSORBATE ATOMS AND TWO-DIMENSIONAL STRUCTURE OF ADSORBATE LAYER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 286, No 1, Jan 86 (manuscript received 20 Dec 84) pp 146-149

[Article by L.A. Rudnitskiy, State Scientific Research and Planning Institute of Nitrogen Industry and Products of Organic Synthesis, Moscow]

[Abstract] The electron work function of a compound metal surface, "polycrystalline" or imperfect monocrystalline, or one covered with a submonolayer film of adsorbate, is generally described in terms of the average electronegativity of the outer layer of surface atoms, weighted by the amount of charge on outer atoms induced by an external electric field. Assuming that the radius of adsorbate atoms is not smaller than the radius of substrate atoms, the change of work function $\Delta\phi$ as a result of adsorption is then related to the surface coverage factor θ by an equation which takes into account interaction and mutual electrostatic shielding of adsorbate atoms as well as the increase of their coordination with increasing surface coverage. This dependence was evaluated theoretically for polycrystalline and epitaxial adsorbate layers, and found to be relatively simpler for adsorbate metals such as titanium crystallizing into a b.c.c. lattice than for adsorbate metals such as silver or gold crystallizing into an f.c.c. lattice. Experimental data have been obtained pertaining to layers of these metals on a tungsten substrate. In the case of epitaxial layers consisting of two monolayers there appears a peak between them on the $\Delta\phi$-θ curve. This theoretically sharp peak has been softened by overlapping rather than strictly sequential buildup of two monolayers, with resulting formation of large two-dimensional clusters which is facilitated by mutual attraction of adsorbate atoms. Figures 4; references 9: 6 Russian, 3 Western.

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PHOTOLYTIC ELECTRON TRANSFER THROUGH BILAYER LIPID MEMBRANE WITH QUINONES AS ELECTRON CARRIERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 286, No 1, Jan 86 (manuscript received 14 Feb 85) pp 150-152

[Article by Ye.Ye. Yablonskaya, Ye.I. Klabunovskiy, V.Ya. Shafirovich, and A.Ye. Shilov, corresponding member, USSR Academy of Sciences, Institute of Chemical Physics, USSR Academy of Sciences, Chernogolovka (Moscow oblast) Department]

[Abstract] $Rh(bpy)_3^{3+}$, a water-soluble electron acdeptor, was injected into a vesicle to serve as electron carrier between $*Ru(bpy)_3^{2+}$ and insoluble quinones such as tripticene quinone, its hydrated derivatives, coenzyme Q_{10}, or 2,6-diphenyl-t-benzoquinone in the vesicle wall. Without a quinone in the vesicle wall, addition of $Fe(CN)_6^{3-}$ to the external acceptor solution does not influence the kinetics of Rh(I)-complex formation upon irradiation by light in the absorption band of $Ru(bpy)_3^{2+}$ and $Fe(CN)_6^{3-}$ is not reduced in the process. With a quinone in the vesicle wall, $Fe(CN)_6^{3-}$ is reduced under light, the quantum yield of this photolytic reaction under steady conditions depending only on the $[Rh(bpy)_3^{3+}]$ concentration and almost not at all on the $[Fe(CN)_6^{3-}]$ concentration up to $2 \cdot 10^{-4}$ M. A higher $[Fe(CN)_6^{3-}]$ concentration, on the other hand, results in aggregation and subsequent precipitation of vesicles. It also does not depend on the [EDTA] concentration and on the quinone concentration, its dependence on the $[Rh(bpy)_3^{3+}]$ concentration being an inverse proportion with the quantum yield of $Fe(CN)_6^{3-}$ reduction becoming 0.15 as the $[Rh(bpy)_3^{3+}]$ concentration approaches zero. The results of this experiment suggest, tentatively, a localization of carrier molecules in a lipid bilayer. Figures 2; references 8: 3 Russian, 5 Western.

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